Engineering APR 25 1918 UNIV

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2.

VOL. CV.—No. 2725.] *LONDON: FRIDAY, MARCH 22, 1918.* [*Registered at the General Post Office as a Newspaper.*] [PRICE 9d. BY INLAND POST ... 11d.

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Specifications, Forms of Tender, and any other particulars required may be obtained upon application at the Office of the Borough Engineer and Surveyor, Town Hall, Barrow-in-Furness, and Tenders, endorsed "Painting, Walney Bridge," must be delivered at my Office at or before Twelve o'clock noon on the 17th April, 1918.
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By Order,
L. HEWLETT,
Town Clerk. K 715

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Canvassing, either directly or indirectly, will disqualify a candidate for appointment.
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Candidates must be ineligible for Naval or Military service.
Applications to be made upon forms to be obtained at my office as below, by transmitting a stamped addressed foolscap envelope.
J. E. P. HALL,
Clerk to the Guardians.
Town Hall,
St. Pancras, N.W.1.
15th March, 1918. K 797

Efficiency Engineer Required, Immediately, for Government Controlled Establishment situated in the Eastern Counties. Only men of sound experience who can show successful results need apply.—Applications to be made to nearest EMPLOYMENT EXCHANGE, stating age and salary required, mentioning this Journal and K 784. No one already on Government work can be engaged.

Vacancy for an Engineer having had experience with, and capable of taking charge of large Water-tube Boilers. Man holding Board of Trade Certificate would be preferred.—Address, K 812, Offices of ENGINEERING.

Wanted at Once, Ratefixer for large firm in Eastern Counties, manufacturing Internal Combustion and Steam Engines. Experienced in fixing Price Rates for machining and fitting on approved modern methods. No one on Government work will be engaged.—State age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and K823.

Wanted, Secretary to Chief Engineer. Good shorthand and typewriting essential. Knowledge of reinforced concrete and ability to draw and trace very desirable.—Write, stating age, experience and salary required, to BOX 373 A, SMITH'S, 21, Bush Lane, E.C. 4. K 824

Responsible Deputy to Works Manager WANTED, at once, for large Engineering Firm. Must have had good experience in well-organized works, comprising engine shops, foundries and boiler shops, and in consequence must be able to assist in improving and maintaining works organization for systematic production. Age 30—36 years; salary £350—£500 per annum, according to qualifications.—Address, K 767, Offices of ENGINEERING.

Wanted, Temporarily, for firm dealing with production of non-inflammable Celluloid and Imitation Horn, an ENGINEER with experience of special machinery for this class of work and able to deal with colour effects in material. Must have experience of Electrical Steam and Water Power. Good salary to fully qualified man.—Address, stating full particulars of experience, EXCLUSIVE BOX 382, care of MITCHELL'S Advertising Agency, 1, Snow Hill, E.C. 1. K 526

Representative Wanted by large firm of Manufacturers and Merchants holding important Engineering Agencies in the North of England. Must be of good address and undoubted integrity, and possess engineering knowledge. District to be covered: Northumberland, Durham, and Cleveland. No person already on Government work will be engaged.—Apply in the first instance, stating age, experience and salary required, to K 635, Offices of ENGINEERING.

A Firm of Controlled Engi- NEERS, with works in the Midlands and London office, REQUIRE the SERVICES of a Live REPRESENTATIVE, who can influence orders for Steam Specialities. Applicants who have first-class connection. Remuneration by salary and commission.—Address, in first instance, K 798, Offices of ENGINEERING. Nobody already engaged on Government work will be engaged.

Engineer Required, to Take Charge of the production side of a Controlled Works in the Manchester District, employing about 150 hands. Must be six o'clock man, energetic, tactful in the handling of male and female labour and be capable of producing results. Machine tool and small tool experience preferred. The position is permanent and progressive. State experience and salary.—Address, K 768, Offices of ENGINEERING.

Wanted, for Rate-fixing Department of Controlled Engineering Works in Manchester District, experienced CLERK. Applicant must have adaptability and initiative for position of rate fixer, and must be of good education and character. State experience, age, military category and salary required. No one already on Government work will be engaged. —Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and K 771.

Works Accountant Required, by large Aero Engine Works in London area. Good salary to competent man. No one on Government work or residing more than ten miles away need apply.—K 820, Offices of ENGINEERING.

Wanted, by a Firm of Public Works Contractors on Government work, CHIEF MECHANICAL ENGINEER. Must have had experience in similar position previously with firm of repute, must have experience of Excavating Machines and Contractors' Plant generally.—Address, with references and state salary required, to K 831, Offices of ENGINEERING.

Wanted, Superintendent ENGINEER, by Glasgow owner, for fleet of 13 steamers, 650/1700 tonners. One with similar experience preferred. Must have good knowledge of hull as well as machinery work, and competent with accounts and surveys.—State qualifications and salary expected to ENGINEER, WM. PORTEOUS and Co., Advertising Agents, Glasgow. K 793

Wanted, Electrical Engineer, for large Iron and Steel Works on North-East Coast. Practical and technical experience essential in H.T., three-phase and D.C. machines. Knowledge of general engineering an advantage. —State age, experience and salary expected to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4303. No person already engaged on Government work will be employed. K 600

Wanted, by Controlled Engi- neering Firm in Manchester District, a First-class RATH FIXER, of good education and character. Must be thoroughly experienced and tactful. State experience, age, military category and salary required. No one already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and K 772.

Structural Engineer Wanted, for Design of urgent War Work in Reinforced Concrete. State age and salary required. No one now on Government work need apply.—BOX 3883, care of Brown's, 29, Tothill Street, Westminster. K 848

Wanted, Assistant Chemist, experienced in the analysis of metals, oils, soaps, paints, organic compounds.—Write, stating age, experience, and salary required, to K 716, Offices of ENGINEERING.

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Assistant Blast Furnace MANAGER WANTED, by a Firm on the North-East Coast. Must have had a scientific training, and technical experience desirable. No person already on Government work will be engaged.—Applications, stating age, experience and salary required, together with copies of recent testimonials, to be made to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4925. K 807

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Applications should be submitted before 9th April, 1918, on Forms which may be obtained together with further particulars of the post, from the REVENUE SECRETARY, India Office, Whitehall, London, S.W. 1. K 802

Analytical Chemist Required, to take charge of the Chemical Section of Laboratory, controlling machine shops, iron foundries and bronze foundry. Candidates must have had first-class experience in the analysis of high speed, alloy and straight steels, and be thoroughly conversant with the chemical laboratory work in connection with iron and bronze foundries, including the controlling of cupolas. Applicants should give full particulars of their training and particularly their foundry experience; also state age and salary required. The position is permanent and holds good prospects for a suitable man.—Apply, ALFRED HERBERT, LTD., Machine Tool Makers, Edgwick Works, Coventry. K 605

Assistant Chemist, Ineligible for Military service, WANTED for large Engineering works in Newcastle-on-Tyne district, one accustomed to analyses of iron and steel or brass and other non-ferrous alloys. No person already on Government work will be engaged. State age, qualifications and salary required to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4856. K 689

Wanted, Junior Chemist, experienced in high-class Steel Melting, for small Electric Steel Furnace.—Applicants must state age, experience and wages required, and apply to their nearest EMPLOYMENT EXCHANGE, quoting No. A 4915. No person already on Government work will be engaged. K 815

Wanted, Experienced DRAUGHTSMAN for elevator and conveyor work on important Government contracts. No person resident more than 10 miles away or already on Government work will be engaged. Reply, stating age, experience, salary required, and when at liberty to BOX 516, T. B. BROWNE'S Advertising Offices, 163, Queen Victoria Street, E.C. 4. K 574

Draughtsman Required, with good experience in design of Steelworks Machinery preferred, although applications from high-class men with other experience would be considered. No one already on Government work will be engaged.—State age, experience and salary required and when at liberty, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4694. K 360

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Wanted, Sheerness District, good Civil Engineering DRAUGHTSMAN, experienced in surveying and general building construction. Ineligible for military service.—Apply by letter, stating age, salary required, full particulars of experience and enclosing copy of recent testimonials, to BOX 1095, WILLING'S, 125, Strand, London, W.C. 2. K 843

Civil Engineering Draughts- MAN REQUIRED, for Government work in Chatham district; should be thoroughly conversant with design of structural steelwork, calculations, &c. Ineligible for military service.—Write, stating age, particulars of experience, salary required and enclosing recent testimonials to BOX 1165, WILLINGS, 125, Strand, W.C. 2. K 844

Wanted, for Manchester Dis- trict, two good DRAUGHTSMEN, conversant with the design of modern high-class Surface Condensers and Accessories for Turbine Installations. Able to estimate and take out quantities correctly and expeditiously.—Apply, with full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and K 817. No one already employed on Government work need apply.

Draughtsmen Required in Government Aeronautical Establishment near London.—Apply, giving full particulars, experience, and technical education, to K 833, Offices of ENGINEERING.

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Wanted, by Engineering Firm near London, a JIG and TOOL DRAUGHTSMAN for General Engineering work.—Apply, stating age, experience, and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4865. No person already employed on Government work will be engaged. K 780

Draughtsmen.—Applications REQUESTED for good experienced Mechanical Draughtsmen. Those with Crane Work experience preferred. State age, salary, experience and when at liberty, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4428. No person already on Government work will be engaged. K 770

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Several Good Engineering DRAUGHTSMEN REQUIRED by large Controlled Firm in Tyne district, manufacturing aircraft. Experience of aeronautical work desirable but not essential. No one already on Government work will be engaged. Good remuneration offered to competent men.—Write, stating age, experience and qualifications, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and K 773.

Wanted, in Westminster, FURNACE DRAUGHTSMAN, accustomed to gas-fired furnaces and gas producers. No one at present engaged on Government work or resident more than 10 miles away will be engaged. Urgent. —Address, K 781, Offices of ENGINEERING.

Wanted, Mechanical DRAUGHTSMAN by Firm of Electrical Engineers; preference given to one accustomed to designing of haulage gears. No one already on Government work will be engaged.—Apply, stating age, experience and salary, to the nearest EMPLOYMENT EXCHANGE, mentioning this paper and K 803.

First-class Draughtsmen with good general experience WANTED by large Controlled Firm in South Yorkshire.—Address, giving full particulars of experience, and salary required (inclusive of War Bonus), J 548, Offices of ENGINEERING J 548

Draughtsman (Electrical), WANTED, for the Midlands. Preference given to men with experience in the design of D.C. and A.C. machines or transformers.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 4895. Nobody engaged on Government work will be engaged. K 740

Draughtsman, Senior and Junior, preferably accustomed to Aero Engine work. Also, LADY TRACER, experienced, REQUIRED, at once. No one engaged on Government work or residing more than ten miles away will be engaged.—Address, K 762, Offices of ENGINEERING.

Draughtsmen.—Wanted, Two First-class DRAUGHTSMEN, preferably men experienced in Iron and Steel Works Design. —Apply by letter, stating experience and salary required, or call personally, INTERNATIONAL CONSTRUCTION CO., LTD., 56, Kingsway, W.C. 2. K 766

Wanted, Experienced Jig AND TOOL DESIGNERS for large Electrical Works in the Midlands. Knowledge of Press Tools an advantage. Good salary and permanency to really capable men.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this paper and No. A 4896. Nobody already engaged on Government work will be engaged. K 739

Draughtsmen (Jig and Tool) WANTED for high-class Aero Engine Repetition Work. Must have good machine shop and some drawing experience. Good salary and overtime pay for keen, practical and intelligent men. No juniors need apply. Persons already employed on Government work will not be engaged. —Apply, nearest EMPLOYMENT EXCHANGE, mentioning No. A 4882. K 795

Civil Engineering Draughts- MAN WANTED, experienced in steel work, construction, and ferro-concrete work. Must be ineligible for general military service.—Write, stating age, experience, salary required, and enclosing copies of recent testimonials, to BOX 1135, WILLING'S, 125, Strand, London, W.C. 2. K 789

Wanted Immediately, for War Office Department in London, first-class DRAUGHTSMEN, accustomed to Crane, Elevator or General Engineering work. No one already employed on Government work will be engaged. State age, salary and experience to your nearest EMPLOYMENT EXCHANGE, quoting K 638, and this Journal.

Engineers, Designers and DRAUGHTSMEN, with previous experience of design of ferro-concrete structures, REQUIRED by L. G. MOUCHEL & PARTNERS, LTD., 38, Victoria Street, S.W. 1.—Apply by letter, stating age, experience, and salary required. K 794

Draughtsman Required to TAKE CHARGE of Coal Washery Department. Experienced men only need apply.—Full particulars in the first place to K 624, Offices of ENGINEERING.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN ordinary general meeting of this Institution was held on Friday last, the 15th inst., at the Institution of Civil Engineers, Great George Street, Westminster, the chair being occupied by the president, Mr. Michael Longridge. The minutes of the previous meeting were read and confirmed, and the secretary announced that 80 candidates had been elected and four transferences made from the class of Associate Members to full membership.

The president expressed his regret that in opening the proceedings he had to make an announcement which he believed the members would receive with some justifiable indignation. For some inscrutable reason, the Special Intelligence Branch of the Ministry of Munitions, to whom the papers of the Institution had to be referred for censorship, had forbidden the reading of Mr. Morgan's paper. He was well aware of the critical relations existing between the Amalgamated Society of Engineers and the Government and of the absolute necessity for suppressing any documents or public discussion which might, by any possibility, aggravate the differences which existed or create a suspicion that engineering employers intended to break, without the men's consent, the pledges they had given; and had the paper by Mr. Morgan suggested anything of the kind it would never have been accepted by the council. On the contrary, the paper had been carefully read and edited by Dr. Maw and himself, and every expression that might have been twisted by mischief makers to promote misunderstanding had been carefully removed. In its approved form the paper contained nothing but a record of what had been done during the war in the employment of women in munition works. The paper had been sent to the Ministry of Munitions on March 2, with a notification that it was intended to read it on the 15th inst. Since the first-named date, Mr. Worthington had been in constant communication with the department by telephone, by letter and in person, without being able to ascertain what the decision would be. On Tuesday (the 12th inst.) Mr. Worthington was informed unofficially, by telephone, that it was probable that the paper could not be read on the 15th. The information reached the speaker on Wednesday morning, and he at once wrote to the department, asking to be apprized officially as to whether the information received by Mr. Worthington was correct; if so, what portions of the paper were objected to, and whether, those portions being deleted, the rest of the paper might be read. He sent the letter requesting that an answer should be returned by the messenger, and he pointed out the great inconvenience caused by the delay. On Wednesday morning Mr. Worthington was informed by letter from the Special Intelligence Branch of the Ministry of Munitions that the Ministry could not consent to the publication of the paper. On the same morning he (the President) received a letter to the effect that the objection to Mr. Morgan's paper was "to its general tenor rather than to any particular portions," and that "the question as to whether Mr. Morgan should have permission to read the paper is one for the Ministry of National Service, and it will be necessary for you to consult them if you desire to be informed officially as to their attitude." Mr. Longridge added that the meeting had the whole case before it, with the exception of the paper. Without reading it they could not therefore judge whether the Ministry of Munitions had any just ground for withholding a valuable record of experience gained, from an Institution composed of men who, it might be thought, would have been entitled to receive it, in the public interest. Nor could they decide why the Ministry of Munitions refused consent, and at the same time informed the institution that permission to read the paper should be obtained from the Ministry of National Service. This, however, he thought the meeting would decide—that the official who, knowing the circumstances, kept back his decision for ten days, had been guilty of a great discourtesy towards the Institution, a body of men representing the most important profession and industry in the country, numbering among its members men who had done as much as, or even more than any except the members of the fighting force to bring the present "mechanical" war to a happy termination.

WOMEN IN MUNITION FACTORIES.

In view of the circumstances outlined by the president, only one paper on the above subject was available for reading and discussion. This paper was entitled "The Employment of Women in Munition Factories," and was by Miss O. E. Monkhouse, M.B.E., B.A.(Lond.), and was read by the authoress. We print this paper in full on page 328 of the present issue.

On the conclusion of the reading. the president heartily congratulated Miss Monkhouse on the cordial manner in which her paper had been received. For a lady to read a paper before the Institution of Mechanical Engineers was an event, and was no doubt an unforeseen consequence of the war, as well as a sign of the times. The paper itself was not differentiated from the ordinary run of papers. It dealt succinctly, from a woman's point of view, with some of the difficulties attending the introduction of woman labour into engineering works; with the special arrangements requisite for the health of women, and the special adaptation of processes to her capacity. The effect upon the race of woman labour in works and its influence upon the comfort and happiness of homes were also dealt with. These considerations were apt to be thrust into the background, but the speaker would urge upon women seeking this class of work, and the privileges of men, to bear in mind the highest work which nature had given them to do and the greater privileges which womanhood conferred. He trusted that nothing would be said in the course of the discussion to aggravate the sexual and industrial differences which shortly would have to be overcome. It was desirable to have the results of experience from those having knowledge, together with the inferences to be drawn. Controversy as to the right of women to take up men's work or as to the nature of the bargain to be struck should be avoided.

Mr. Charles Wicksteed opened the discussion. He observed that his experience in the employment of women commenced about three years ago at Northampton. He had about 100 girls, and these were worked in three shifts. He had done his best to consider their comfort, and had provided ample lavatories and hot water supply, together with a canteen, and for the country girls, a dormitory, with the result that the women were happy and well. He had no sympathy with extravagant appreciation of women's work, but he thought, in view of what might have been expected, they had done exceedingly well. Of course, troubles had arisen from the inexperience of the girls and from the inexperience of his own people, as well as that of Government inspectors. It was difficult to make anything which would be fool-proof, and perhaps impossible to make anything "girl-proof." Of the shells made at his works a girl would turn our two complete 4.5-in. shells or one 6-in. shell in a day. At first many wasters were produced, but the present rate was only 1½ per cent.. As to the prospect of making engineers of women he was not hopeful. On what he might term the fringes of engineering, the women could work to advantage; certainly in small duplicated work, involving machinery of no great cost, work in which one woman could readily be replaced by another. But they could only achieve the result at a certain cost, and they were entirely unsuited for engineering work properly so called. Mr. Wicksteed considered that social influence and environment would adversely effect girls in works, as compared with boys. Generally speaking, the girls could only work advantageously on a single article, that and nothing else. The real engineering work was done by men, and for shell work men of the greatest skill were needed. He would mention that at his works working in day and night shifts, one tool setter was sufficient for 25 girls, and during the night shift the turnout came within 5 per cent. of the other shifts. To turn to the disqualifications. In his experience, where 10 out of 100 men left in a year, 50 out of 100 women would leave, while with regard to time-keeping a woman would lose six days in a 100 where a man would lose only one day. He had known instances of seven women being off in one night, two or three of them perhaps engaged on a job which required considerable training. There were, he felt, numerous reasons why women were more liable to break time than men. Women were less to be relied upon than men, and although as his experience extended he was better and better satisfied with them, he was convinced that girls would not be required when the war was over, except in the small trades. So strong was his conviction that he had initiated at his works an unemployment fund, and had persuaded almost all the women workers to allow him to reserve for each 3*s*. per week from their earnings, to which he had added another 3*s*. The fund thus created would be paid out again at the rate of 10*s*. or 15*s*. a week when unemployment supervened. The forethought indicated by the general acceptance of this proposal had been both surprising and gratifying to him. He was anxious not to be misunderstood, and therefore would express his high appreciation of the work which the women did. It was, indeed, marvellous how girls who had never seen a machine, would, in a few days, sometimes in a few hours, work successfully. Of course there might be potential engineers among women, but the ordinary woman was attracted simply by pay, and was not an engineer in any sense of the word. Women would never be fit for the prolonged training—never done with—essential for the making of an engineer.

Mr. Robert B. Creak spoke next. He desired to refer to three points in the paper which he regarded as important. Miss Monkhouse had mentioned the value of special training schools in bringing women to a state of high efficiency. He would like to emphasise the still greater importance of this factor in the case of male apprentices, in view of Mr. Wicksteed's estimate of comparative capacities. So also with the question of shorter shifts; he was confident that increased output would follow shorter hours for men, especially the elimination of early morning hours. Finally, he thought that the money-making value, from the output standpoint, of welfare work would result equally if such work were carried on in the case of men.

Mr. James Hartness, a past-president of the American Society of Mechanical Engineers, remarked that during his present visit to England this was the first occasion on which he had had an opportunity, as a member of the Institution, of attending one of the meetings. In the first place he desired to convey to the council and the members of the Institution the greetings of the American Society of Mechanical Engineers. Mr. Hartness, who was in England in connection with aircraft standardisation work, was returning to America the next day, and he proposed to give America such an account of what he had seen of women's work in England as would be most stimulating to patriotic feeling, self-denial, and the other things for the carrying out of which stimulus was needed on the other side. He intended to take with him a picture of what he had seen of woman's work in the munition shops of this country, of how they worked at the close of a long shift and the nature of the emergency work they did. He had himself worked in the shops all his life and knew what was meant by work. Yet be confessed that he had never seen such a sight as he had witnessed in a shop full of women, where all were moving and busy. He was convinced that the women were not working merely for money: money could not inspire such work. On the contrary they were working for service in a spirit that he did not think men could boast of. In connection with the remarks that had been made about the coming and going of men and women, he believed that if women became accustomed to shop work, and ordinary conditions were reversed, 50 per cent of the new men would be lost. It was only to be expected that women, being new to the work, would show a higher percentage in the matter of leaving. In conclusion, he might mention that he had been a guest of the Institution in 1910, and had always found it a great pleasure to keep in touch with it.

Mr. Richard W. Allen remarked that, as an employer of a large number of women, Miss Monkhouse had his entire sympathy in her views. The paper was written by one who knew the subject

from A to Z. Miss Monkhouse had rightly urged that success depended largely upon the sympathetic attitude of the employer. He recalled that in the early stages of the war, when there existed a difficulty in obtaining men and a need for increased production and for new production, he had been told by a representative of the Ministry of Munitions that it would be necessary to employ women. On grounds of loyalty his firm had agreed, somewhat under protest. He had explained the situation to the foremen, who accepted it in a sportsmanlike spirit. They had never since looked back, notwithstanding the complicated nature of the work to be done. It might be true that women were mainly suitable for repetition work, but he believed that patient teaching would render women equally as serviceable in general engineering as in manufacture, notwithstanding the wide difference. The speaker insisted upon the necessity of giving the women a chance by adequate teaching. He would submit particulars of the work his women employees were at present engaged upon, mentioning a complicated aviation engine and turbines for the Admiralty. In the case of the latter the women were taught to do the work of blading. Fitting work was also taught. In view of the title of the paper, he was surprised that anyone should have thought there was any suggestion of turning out women engineers. Of the three classes of women indicated in the paper his firm had experience only of the first and the second, but he endorsed the opinion that women of higher education rose to the top more rapidly and grasped the character of complicated work more easily than those who had received little or no education. It was difficult to avoid patting the women on the back, so to speak, when observing their attention to their work and their expedition in dealing with it. He agreed wholly with the view expressed in the paper that women employees should be made happy, should be given good dining halls and all the various conveniences, and should be made to realise that they have the employer's sympathy. In such circumstances women would never "let their employers down."

Mr. Rankine said that while much was heard of what women were doing in works, little was recounted of their doings in training centres. Miss Monkhouse had suggested that the best success had been achieved where the training school had been set up in the workshop, but many modern workshops, particularly in London, had not the necessary accommodation. That meant that the women must mix up in the factory, without the advantage of regular preliminary instruction. In a training centre women were, to begin with, medically examined. Cases of physical unfitness were determined within a week, thus avoiding the disappointment consequent upon going into a factory and being afterwards turned down. If physically fit, girls in training centres would learn their work in shops well equipped with modern plant, where they were overseered and taught by skilled men and trained teachers. In a workshop the experienced and well-informed engineer would probably find great difficulty in imparting his knowledge, indeed might entirely fail in doing so. Another argument in favour of the training centre was that if a highly skilled woman, with refined surroundings, entered a workshop in ignorance of its hardships, she might be incapacitated at the outset, whereas at the training centre she would be graduated in her progress towards factory conditions. In a factory, too, someone—perhaps the tool setter—might spoil a girl's chances of success by lack of sympathy, which would not be the case where, as in the training centre, the instructor's specific and only duty was the training of women. Mr. Rankine proceeded to indicate other advantages afforded by the training centres, among others, their function of keeping in touch with employers and filling their wants. At the training school girls would set up their own tools and were ready to work after four or five weeks. They were kept on intensive training, setting up box tools, for instance, exactly as in the factory, and were then ready for doing that particular operation. At the speaker's centre, it was the practice for girls to come to them from the workshops, and work, in the evening, on operations about which they were not clear. As the women were expected to work with fair accuracy, they had to acquire the use of micrometers, verniers, gauges and so on. But the foreman in a works had no time to spare for instructing a woman in the use of the micrometer or how to reduce decimal to vulgar fractions. The training centre had facilities for teaching adequately the use of the various types of instruments.

Mr. W. H. Allen said that notwithstanding the fact that Miss Monkhouse viewed the subject of the paper from outside while the engineer regarded it from within, he nevertheless agreed with all she had said. Not only should the foreman be in sympathy with the women workers, but also the director. He regarded as of great importance a woman supervisor, who would act the part of mother and sister, take them on and put them in their proper places. His son, Mr. Richard Allen, had omitted to mention that he was able to employ about 900 women. His firm had been successful in obtaining a lady supervisor who chose the girls and placed them herself, and in not a single instance had the management regretted her choice. He believed in leaving the girls alone, when they would do their work. He disagreed with Mr. Wicksteed's opinion that women would not be employed after the war. As a seafaring nation, unable to provide ourselves with sufficient food at home, we had to purchase what we needed by means of our industries. Before the war the Germans had our trade, and if, after the war, we did not propose to let the Germans in again, we should require the assistance of women; we should need them as much in the future as now. Miss Monkhouse had stated that a million girls were employed, but, on the authority of Mr. Kellaway, the number was about one and a half million. He suggested that girls should be properly apprenticed as boys were. He hoped no trade union would be offended if he pointed out what a valuable asset for the engineering industries would be found in the employment of one and a half million more people; there would be work enough for both sexes. Miss Monkhouse had put forward the hope that the employment of women would not be allowed to effect the health of the race. That question was important. He trusted we should not return to the days of Earl Shaftesbury, who, as a great philanthropist, passed his life in ameliorating the lot of women and children; nor to the conditions in Welsh mines in the 'sixties, when women could be seen on their knees, with chains between their legs, dragging the trams. He did not advocate the German practice of employing women on shipbuilding; on the other hand, for such work as aeroplane-making they were admirably suited. In consequence of the removal of men, women were indispensable in the trade which was our salvation. He hoped, however, that the Government would see that they were not overworked. The speaker had invited Miss Monkhouse to his works in order that she might find what fault she could. Every effort, however, was made to do the best for their women employees.

Mr. L. A. Legros, the next speaker, observed that he had had some experience in the employment of women in pre-war days on extremely accurate work, apart from his work with the Ministry. The work on which he had engaged the women was the cutting of punches for printers' type, done to the limit of one-fourth of a thousandth of an inch, for straight lines and curves. It was extremely difficult to reduce such work to a matter of figures, and prevent it from being criticised by a foreman, who would condemn the work as wrong if he thought so, or if he desired to prevent women doing that particular work. He had personally trained four women, but only made a success of one. He spent two hours a day for six months on the training, but she succeeded in three trades, the pay for which was 5*l.* 10*s.*, 4*l.* and 3*l.* 10*s.* per week—skilled labour prices. The punch had previously occupied men an hour to cut; the woman cut one in 22 minutes, and he had seen her do one in 15 minutes. The machines were modified, made fool-proof, but not "girl-proof." The girl had to learn to set her machine and not to break the point of the tool. As, however, the men strongly objected to a woman doing this work, they supplied soft cutters, which the speaker hardened himself. As a result, the foreman brought one or two cutters to him, stating the women had hardened them themselves. Eventually that foreman had to go. As an instance of what women could do the point was of interest. So long as women were not put on to lifting weights greater than 50 lb., or called upon to exert more strength than would be reasonable for a boy of 16 or 17, women could hold their own. A good deal of bad training of women existed in the shops; the women were put on filing plates, and instead of marking the line and showing them how to hold the file, they merely gave them the pieces and a steel filing gauge. In nine cases out of ten the foreman did not trouble about the women, only about getting the work done; they would put the hardened steel gauge on the side of the plate next to the woman, so that the plate would chatter and vibrate on the other side, and the file was worn out by rubbing on the hardened steel filing gauge. Again, not realising that women were shorter than men, the vice was placed at the height customary for the men, whereas it should have been at elbow height. As an example of the more difficult work done by women, the speaker instanced the manufacture of stay wires in a shop where aeroplane parts were made. The wires had a small square formed on them in the process of manufacture just under the screw head; these were planished down like a sewing machine needle. To file an $\frac{1}{8}$-in. square or flat near the end of a wire with a screw thread beyond was a difficult job, but the girls learnt to turn these out in less time than they could be got from the manufacturers. On light and accurate work, such as marking off and setting out, some of the ladies had done extremely well. As one speaker had referred to the time occupied in making shells, he would say that he had seen a 9·2-in. shell, with a base screw, turned out in 238 minutes, less than half the time occupied by men in the best works. This remarkable result was in part due to the machine, but in part to women labour; and this was in a works having 95 per cent. women. Miss Monkhouse had alluded to educated women, and, in this connection he would remark that there were two kinds of education; one was the mental education, producible, as it were, by the yard; the other, harder to obtain, was manual education. The girl he had taught to do the difficult work he had referred to was an artist, who could paint a good portrait. There were women to be found who had the required manual ability, but they needed hunting for in the schools of sculpture and in other technical schools. Such work as the production of aircraft propellers, regarded as only suited to highly skilled pattern makers, was usually broken up among three or four women each doing a portion; the combined result, however, equalled that of the pattern-maker. At Panhard & Levassor's works in Paris they had a school run by old and disabled men, through whose hands all the apprentices had to go. Before passing into the shops, a certain time had to be spent on this elementary work. The remainder was spent in the shops, and that finished, they were sacked, so that they might spend two years at least in other works and gain wider experience before being taken on again. In the result the firm always had more applications to come back than they could accept.

At this point the president adjourned the discussion to the next meeting, which would take place, he said, on May 3, and not on the third Friday in April. The delay was necessitated partly by the Easter holidays and partly by difficulties with the printers, arising out of the war. He hoped those who had come prepared to speak that evening would be present on May 3. Possibly—but he could not yet be certain there would be presented a cinematograph show of women's work.

THE STANDARDISATION OF GOODS WAGONS IN THE UNITED STATES.—We read in *The Iron Age* that a step in the standardisation of goods wagons was taken on February 14 by Director-General McAdoo of railroads in the appointment of a committee of manufacturers to recommend specifications for comparatively few types of wagons. Mr. I. M. Vauclain, Baldwin Locomotive Works, is head of the committee and the other members are Mr. W. H. Woodin, New York, president of the American Car and Foundry Company; Mr. J. M. Hanson, Pittsburgh, president of the Standard Steel Car Company; Mr. N. S. Reeder, New York, vice-president of the Pressed Steel Car Company; and Mr. C. Runnels, Chicago, vice-president of the Pullman Company.

TRES SARGENTOS ELECTRIC SUB-STATION, BUENOS AIRES.

Fig. 50.

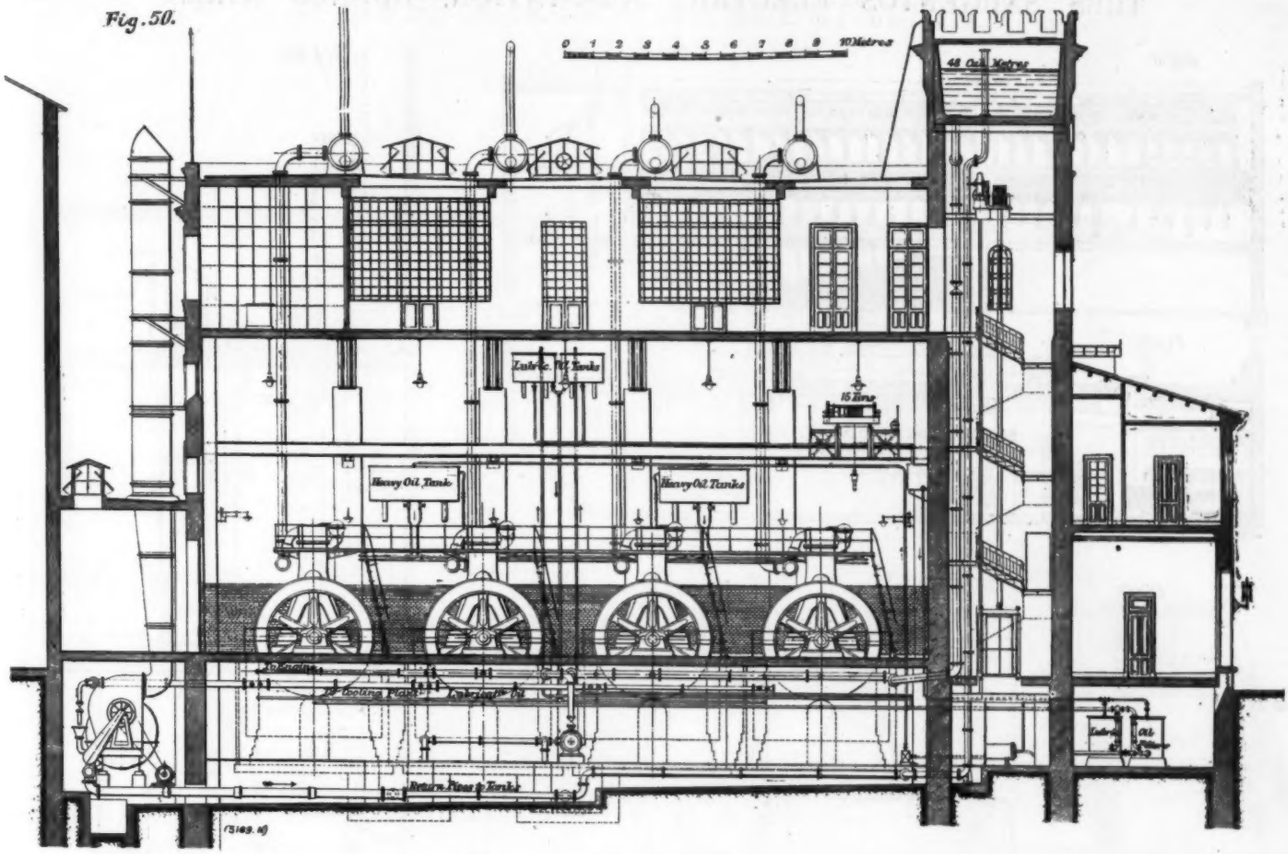
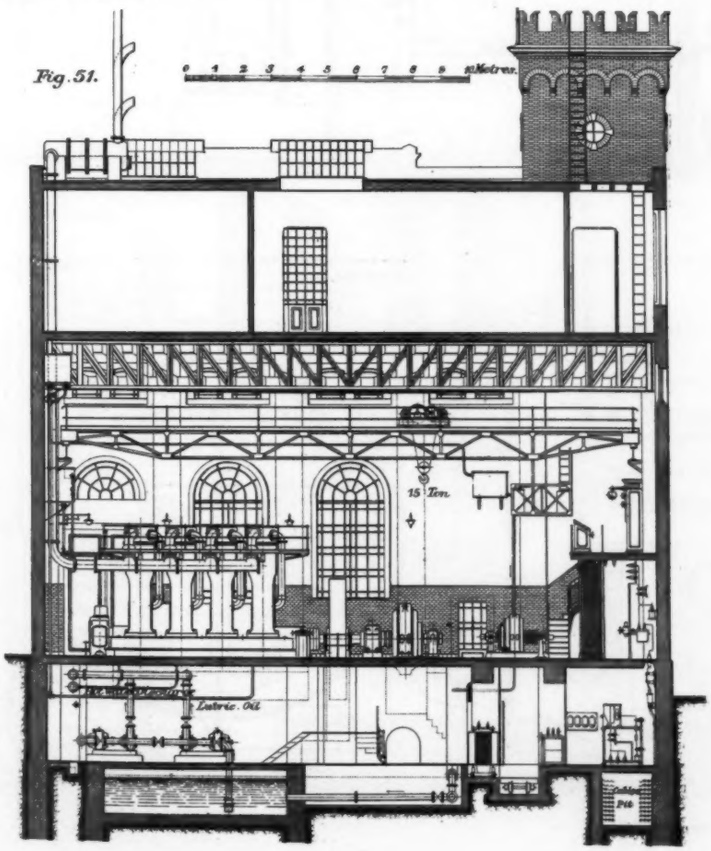


Fig. 51.



ELECTRIC POWER SUPPLY AT BUENOS AIRES.

(*Concluded from page* 223.)

FROM the main generating station at Pedro Mendoza current is supplied to five motor-generator sub-stations, the sites of which have been carefully selected so as to secure the highest possible efficiency in the service provided. At these sub-stations the 7,000-volt three-phase current furnished by the Pedro Mendoza plant, is converted into continuous current. This is distributed to consumers on the three-wire system, with 445 volts to 480 volts between the outers. An unusual feature in the arrangement of these sub-stations is the replacement of reserve batteries by Diesel-driven generating plant. These can be started up so quickly that they are nearly equivalent to batteries so far as provision for sudden overloads is concerned, and they are regularly used for taking peaks, being run in parallel with the rotary converters. In the aggregate the plant at the five sub-stations comprises 13 of these Diesel-engine generating units, each rated at 500 kw. The rotary converters are also 13 in number. Of this total, eight are rated at 1,000 kw. and five at 500 kw.; each is of the six-phase type. The subsidiary equipment includes Heenan water coolers for dealing with the circulating water of the Diesel engines and pumps for oil fuel and lubricants.

In Figs. 50 and 51 annexed, and Figs. 52 and 53, on Plate XXIX, we give sections and plans of the principal of these sub-stations, that at Tres Sargentos. The photograph reproduced on Plate XXXI, Fig. 56, shows that similar care has been devoted to securing a good architectural effect as in the case of the main power station. Interior views of the Tres Sargentos station are reproduced in Figs. 54 and 55, Plate XXX, whilst Fig. 57, Plate XXXI, shows the engine-room at the Balcarce station.

At Tres Sargentos the engines and rotary con-

TRES SARGENTOS ELECTRIC SUB-STATION, BUENOS AIRES.

Fig. 61.

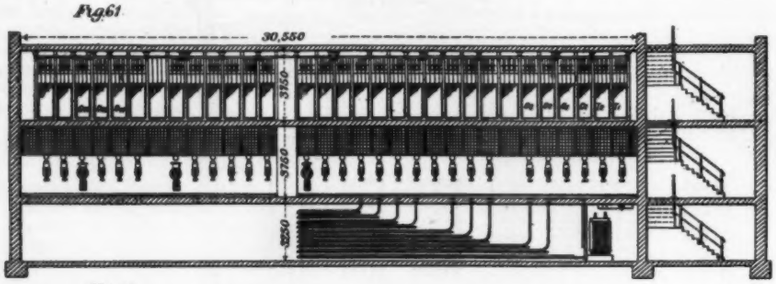


Fig. 62.

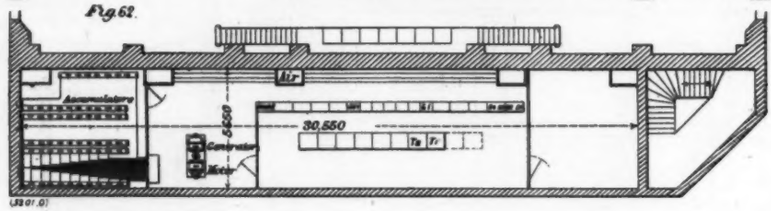


Fig. 64.

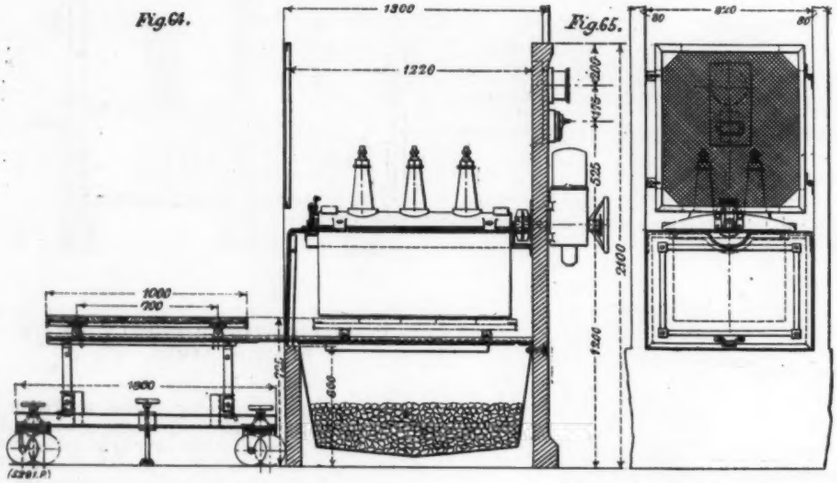


Fig. 65.

Fig. 68.

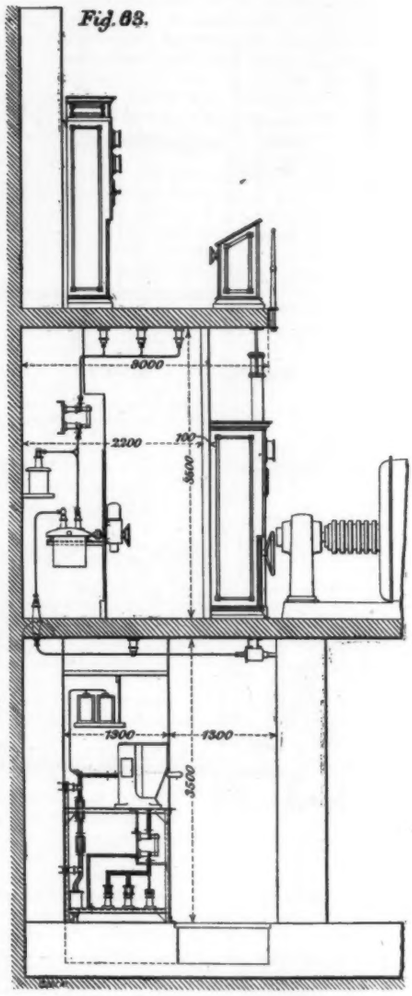


Fig. 66.

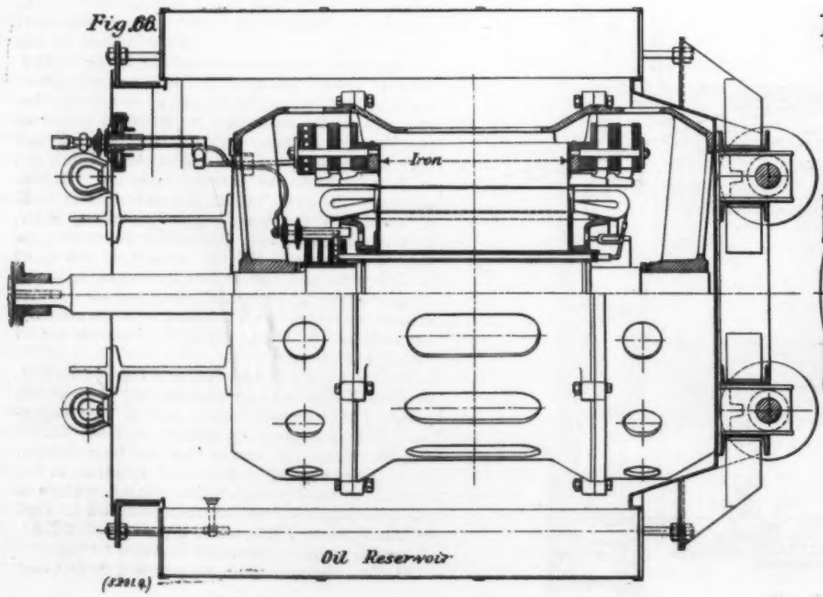
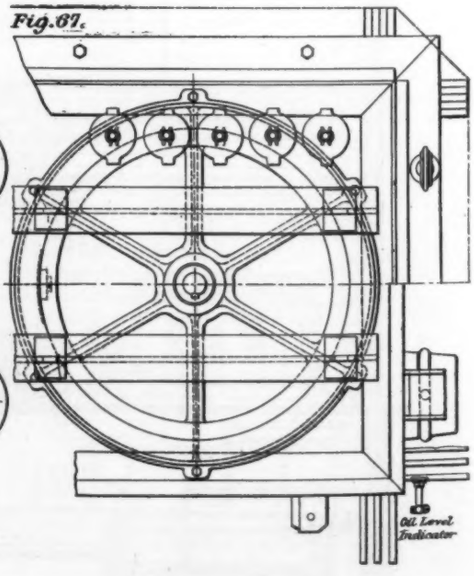


Fig. 67.



ELECTRIC POWER SUPPLY AT BUENOS AIRES; PLANS OF THE TRES SARGENTOS SUB-STATION.

(*For Description, see Page* 301.)

Fig. 52.

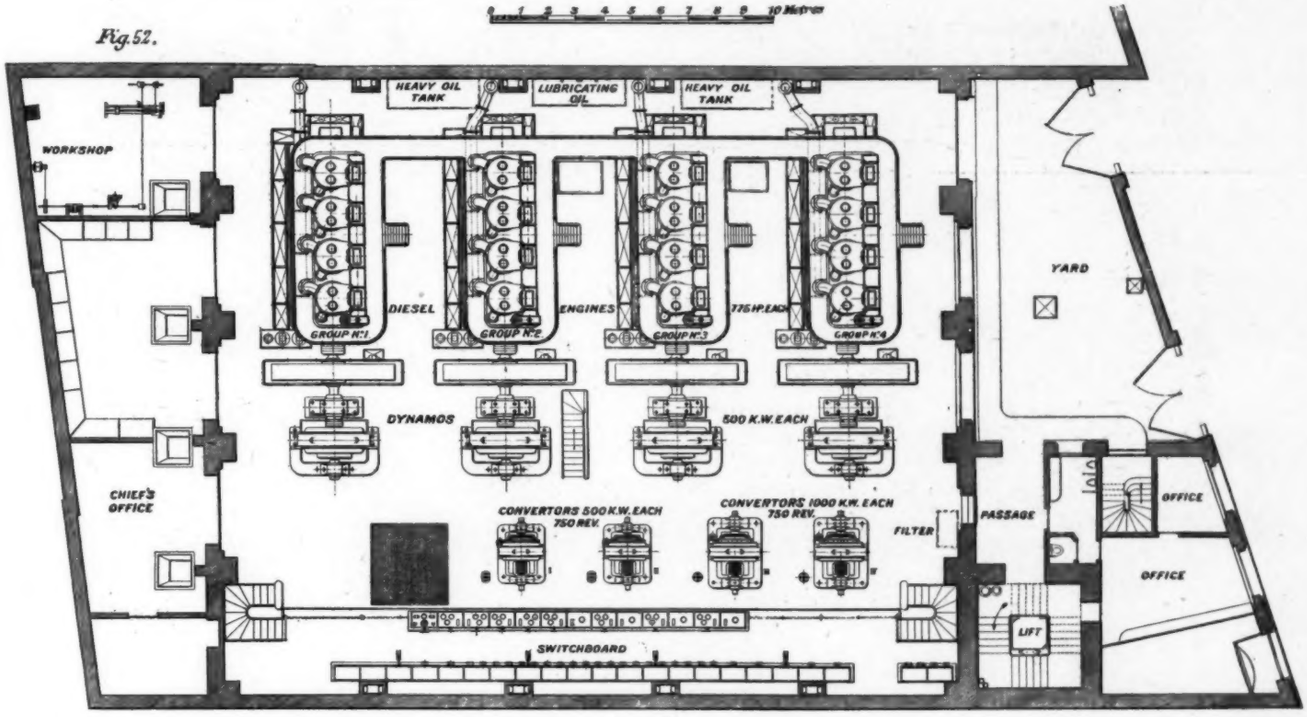
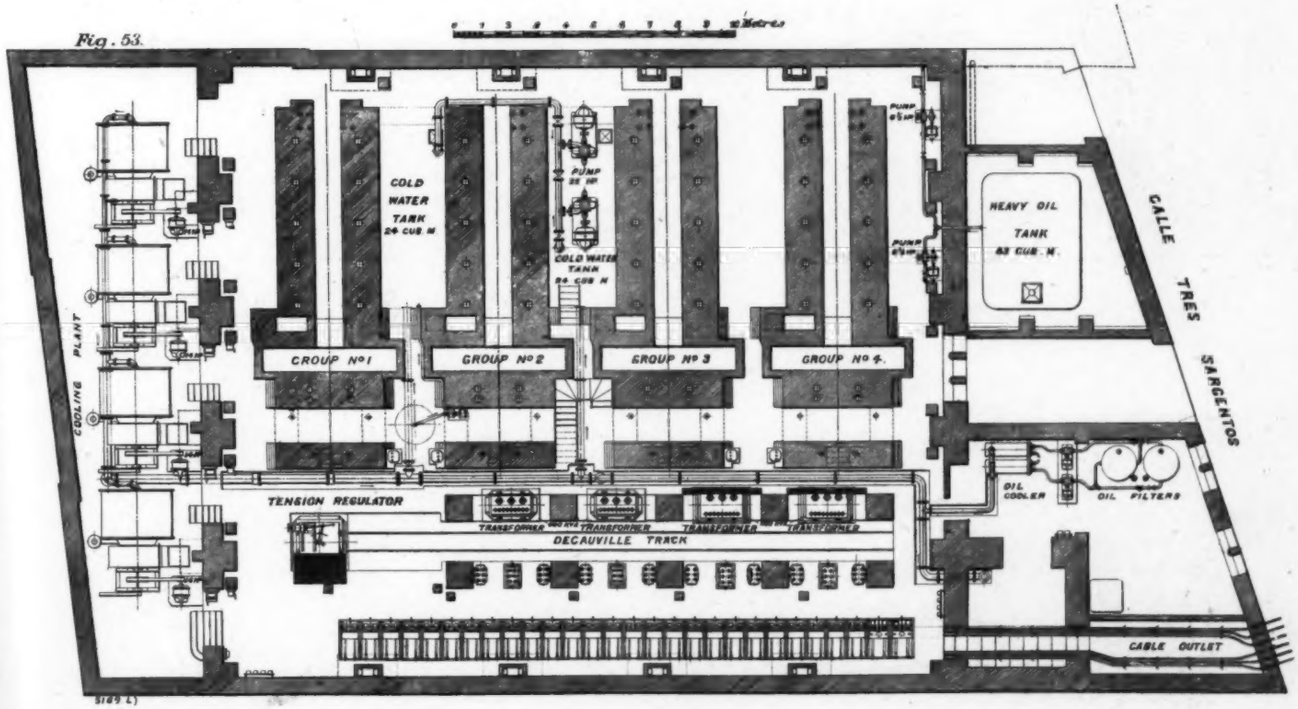


Fig. 53.



(*To face page* 302.)

ELECTRIC POWER SUPPLY AT BUENOS AIRES; PLANT AT THE TRES SARGENTOS SUB-STATION.

(*For Description, see Page* 301.)

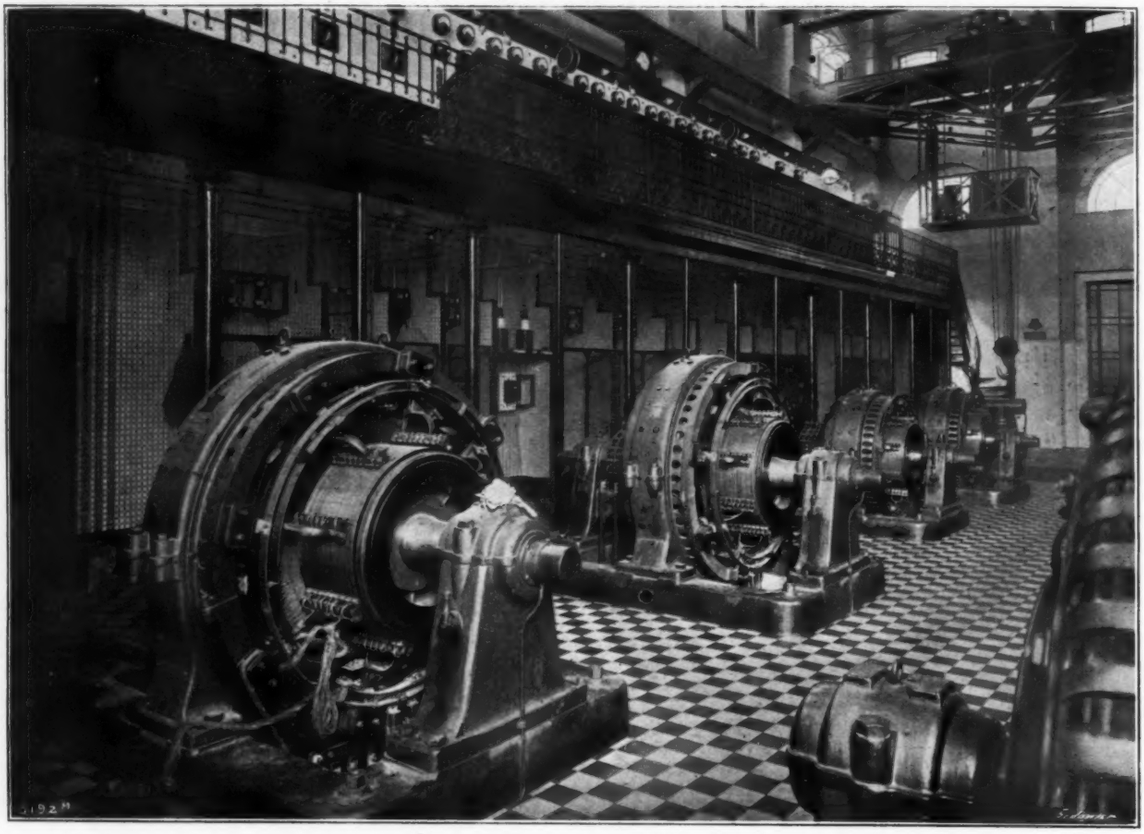


Fig. 54. Rotary Converters at the Tres Sargentos Sub-Station.

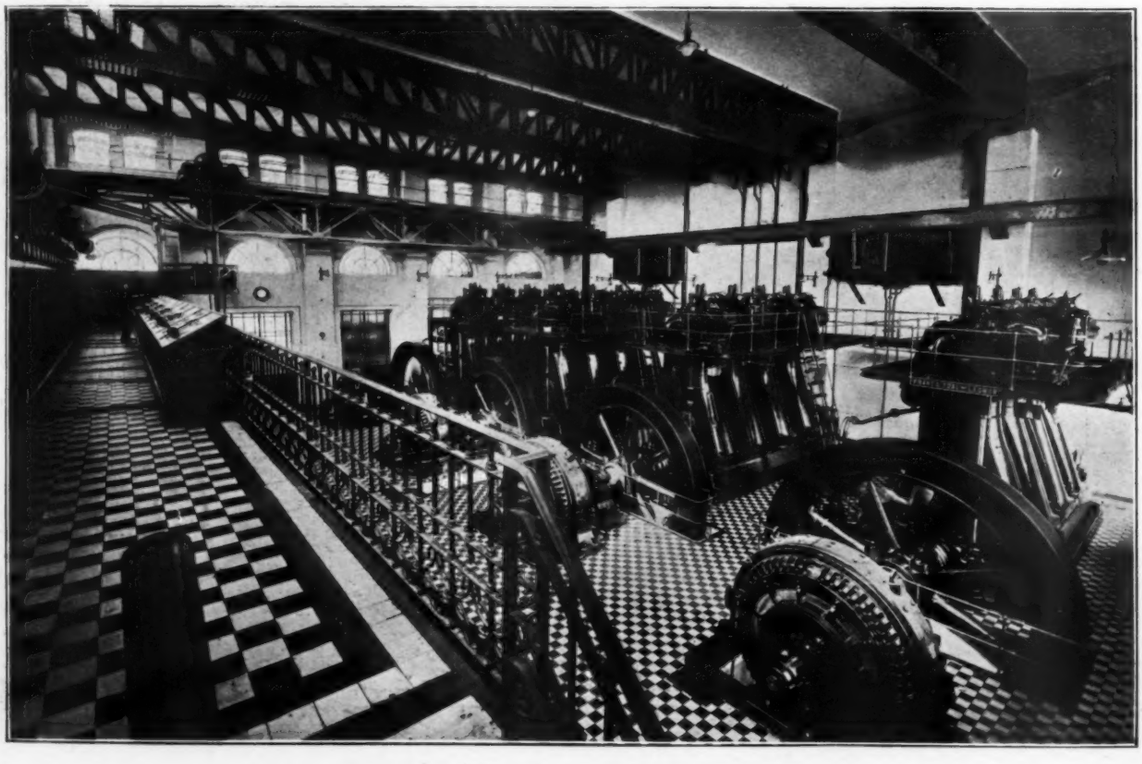


Fig. 55. Diesel-Driven Generators at the Tres Sargentos Sub-Station.

ELECTRIC POWER SUPPLY AT BUENOS AIRES.

(*For Description, see Page* 301.)

Fig. 56. Exterior of Tres Sargentos Sub-Station.

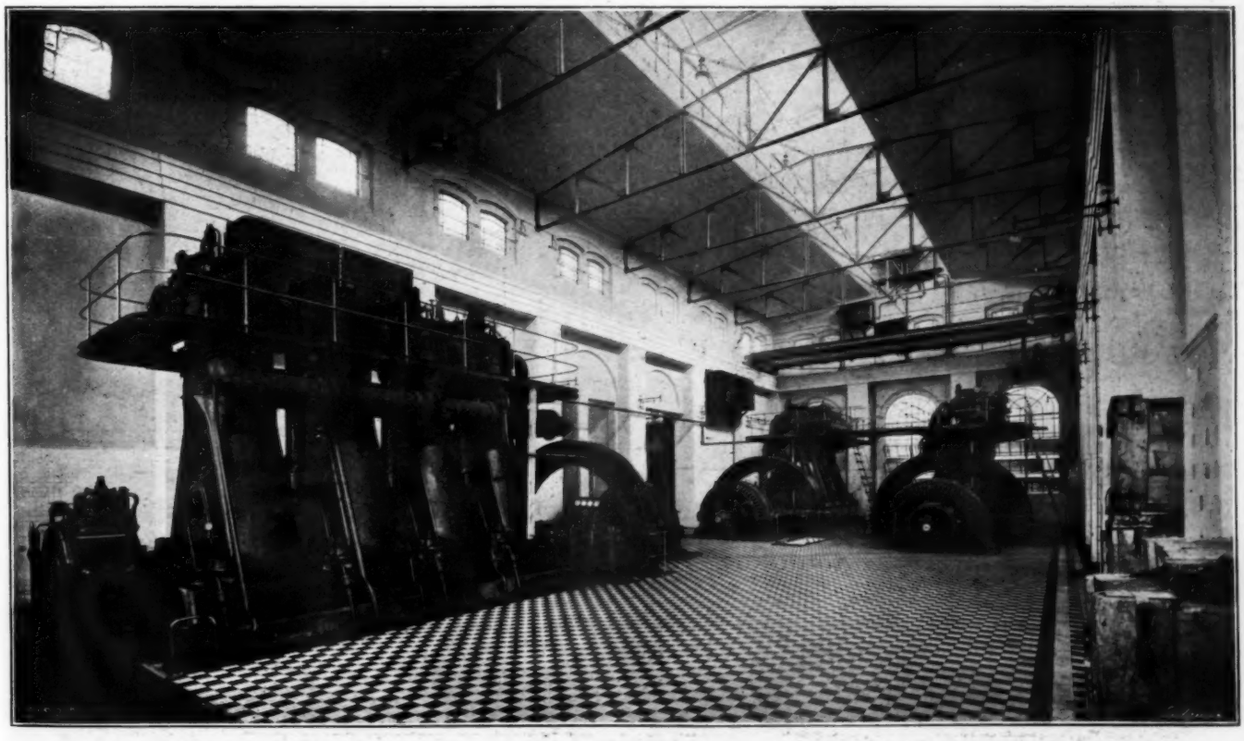


Fig. 57. Diesel Engines at Balcarce Sub-Station.

ELECTRIC POWER SUPPLY AT BUENOS AIRES; SUB-STATION PLANT.

(*For Description, see Page* 301.)

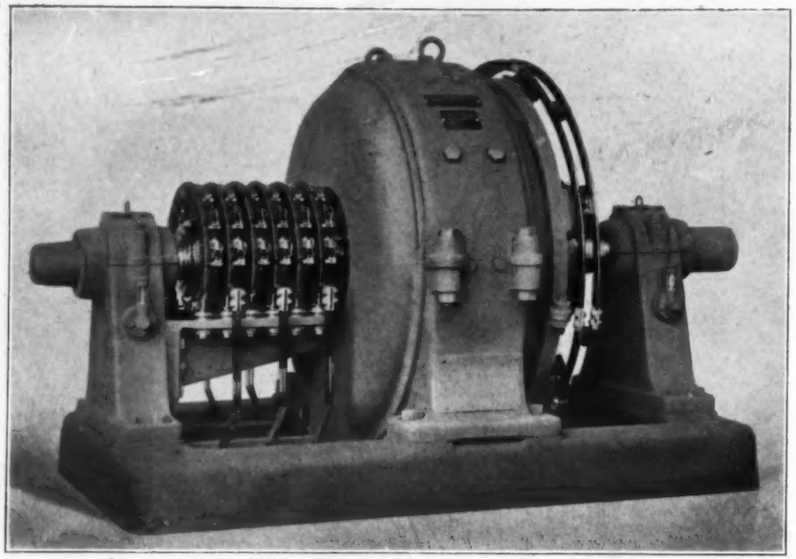


FIG. 58. SIX-PHASE CONVERTER FOR SUB-STATIONS.

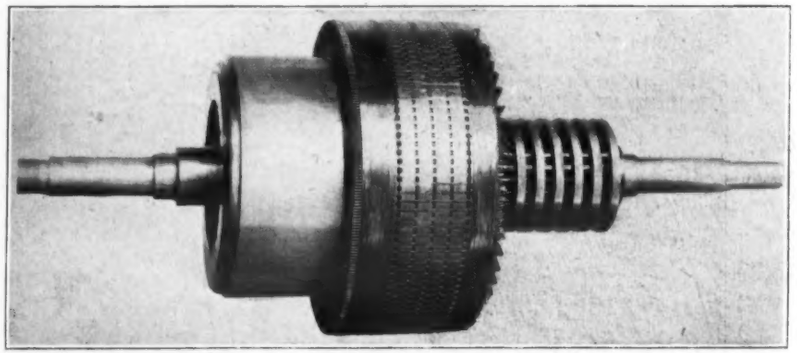


FIG. 59. ARMATURE OF SIX-PHASE CONVERTER.

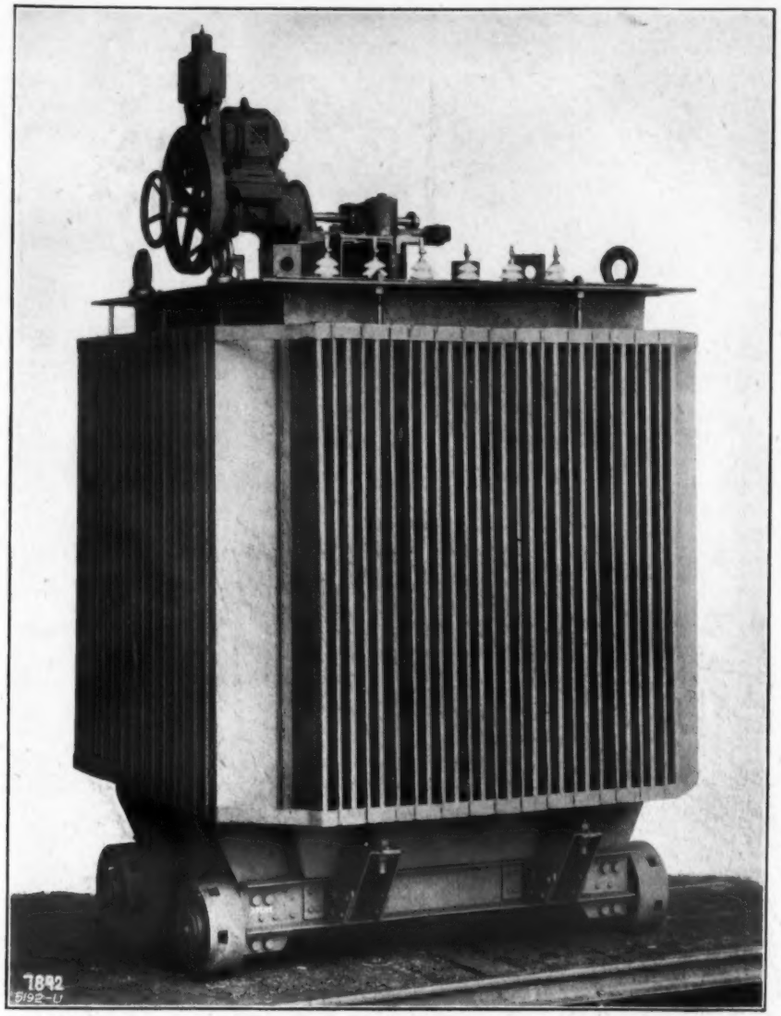
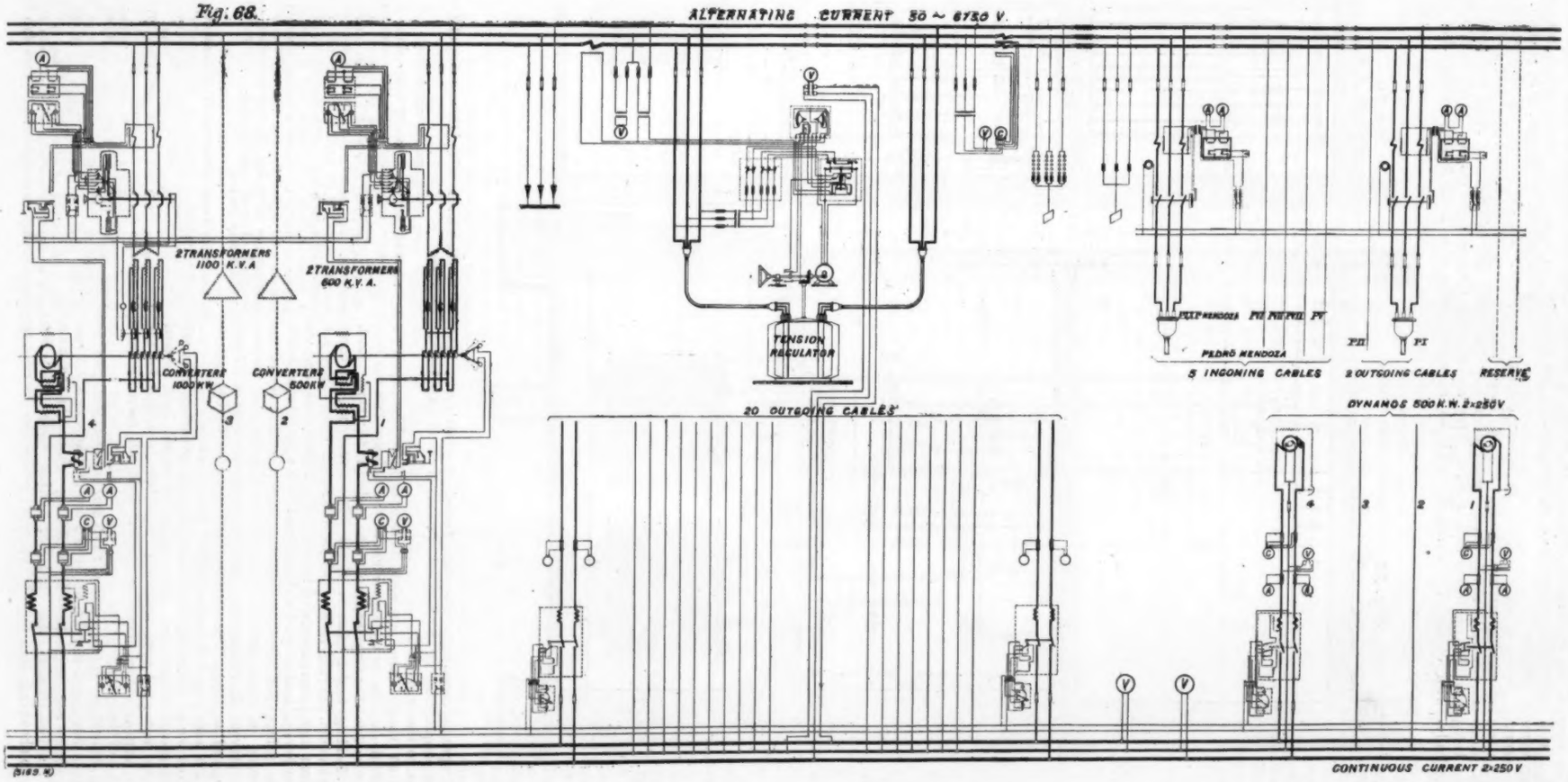


FIG. 60. OIL-COOLED INDUCTION REGULATOR.

(*To face page* 303.)

ELECTRIC POWER SUPPLY AT BUENOS AIRES; CONNECTIONS AT TRES SARGENTOS SUB-STATION.

Fig. 68.



verters are erected in the same machinery hall as shown in Figs. 52 and 53, Plate XXIX. The offices and the workshop are on the same level, but below these is a basement in which the cooling plant is accommodated, as shown to the left, in Fig. 53. On the right, the oil coolers and filters are installed in another basement, and here also in the tower, as shown in Fig 50, page 301, is located the main fuel tank, from which the working tanks in the engine-room are supplied. This main tank holds 83 cub. metres of oil. Interior views taken in the Machinery Hall are reproduced in Figs. 54 and 55, Plate XXX.

The four-cycle four-crank Diesel engines used at the sub-stations were all built by Messrs. Franco Tosi. They are intended to develop 775 brake horse-power in normal running at 145 r.p.m., with a fuel oil consumption of 185 grammes (0.408 lb.) per brake horse-power-hour. When required they can develop a maximum of 890 brake h.p. Each engine is directly coupled to its dynamo. It has four cast-iron cylinders. The bedplate is a single casting. The flywheel provided is sufficiently heavy to prevent the cyclical variations in the speed exceeding 1 in 200. The shaft is a steel forging, flanged at one end for coupling to the dynamo shaft. Forced lubrication is fitted throughout, the oil-pumps being of the usual gear-wheel type. The oil, after escaping from the bearings, is collected in a sump, and filtered and cooled before being returned to the bearings again. The cylinder cooling water is taken direct from the city mains, which provide sufficient pressure, but special pumps are fitted for furnishing the supply to the pistons. Careful provision is also made for cooling the valves, and the whole of the valve and governor gear has been designed with a special view to providing for the easy accessibility of the valves for examination or replacement. A shock absorber is provided between the governor and its gearing.

The converters are of the six-phase pattern, and were supplied by Messrs. Brown, Boveri and Co. One is illustrated in Fig. 58, Plate XXXII, and its armature is shown separately in Fig. 59.

The cables enter the station through a subway which is extended under the switchboard platform. This platform, as indicated in Fig. 51, page 301, is raised above the general floor level of the machinery hall. The general arrangement is well shown in Figs. 61 and 62, page 302. A diagram of the connections is reproduced in Fig. 68, above.

The bus-bars, to which the incoming feeders are connected, do not supply the transformers for the rotary converters directly, but induction regulators of the general type illustrated in Figs. 66 and 67, page 302, are interposed between the feeder bus-bars and the transformer bus-bars. A series transformer actuates a Brown, Boveri, automatic regulator, which controls the motor operating the induction regulator, so that the latter automatically varies the pressure on the transformer bus-bars in accordance with the load on the rotary converters, this pressure either being held constant or raised with increasing load, as may be desired. As indicated in Fig. 68, there is no switch gear on the secondary side of the transformers supplying the rotary converters, all the switching being done on the high-tension side by means of electrically-operated

oil switches with no-pressure release of the type shown in Fig. 41, on Plate XXI, published with our issue of March 1st. The rotary converters are arranged for starting up from the direct-current side, and the middle wire of the three-wire system is taken to a balancing coil connected to the transformers supplying the rotaries, the system being thereby maintained in balance. The electrically-operated three-phase oil switches are of the type used in the main power station. They are illustrated in Figs. 64 and 65, page 302. Each is provided with a form of relief valve to protect the switch from expansion in the case of the generation of gases under pressure. As will be seen from Fig. 64, a tray is provided below the switch. This tray contains a non-combustible absorbent for any oil that may be thrown out of the switch under abnormal conditions. The arrangement for removing the switch for inspection or repairs will be noted on the left of Fig. 64. This consists of a little trolley, which is wheeled up to the compartment, a small carriage at the correct height being provided on the table of the trolley. This can be run into the compartment under the switch and the two then withdrawn together.

The general layout of the switch gear compartments, &c., for the rotary converters is illustrated in Fig. 63. The operating panels are located on the gallery, the electrically-operated switches and the current transformers, isolating switches, &c., being placed on the floor level, while the pressure transformers, bus-bars and cable terminal boxes are in the compartments in the basement. Further details of the switchboard arrangements are illustrated in Figs. 69 and 70 annexed.

The oil-cooled induction regulator is of the general type illustrated in Figs. 66 and 67. It is shown in place, mounted on its oil tank, in Fig. 60, Plate XXXII. It constitutes an automatically-operated and automatically-adjusted induction regulator which, placed at the sub-station ends of the feeders, enables the rotary converters supplied by these feeders to operate under direct-pressure conditions.

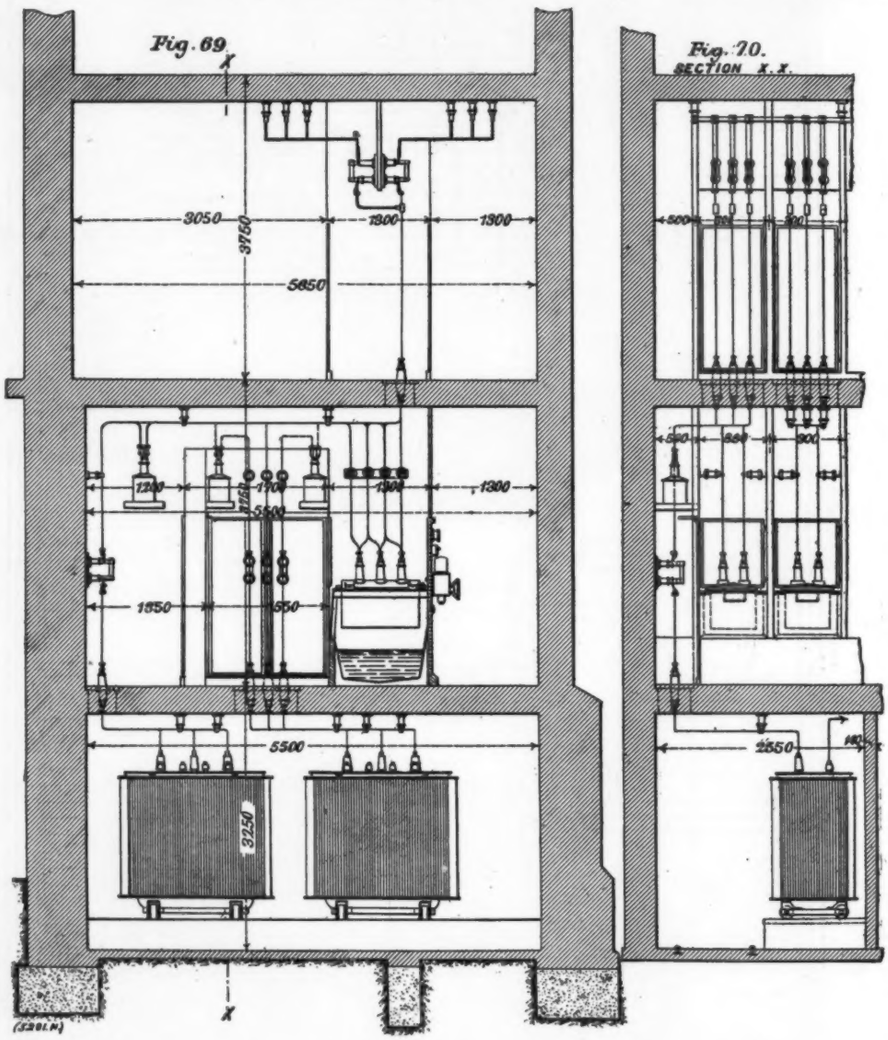
The regulator consists essentially of a light cylindrical armature placed between the poles of an electro-magnet. There are four poles, of which the windings of opposite pairs are in series, but a resistance coil is interpolated in the circuit of one of these sets of windings, and gives rise to a phase displacement in the current passing through it. In this way a rotating magnetic field is produced which tends to displace the armature already mentioned. The value of this torque depends upon the voltage, and it is resisted by a set of springs compensated to produce a nearly constant torque on the armature in opposition to that due to the rotating field. A contact-piece mounted on the armature cuts resistance in or out of circuit as the conditions require. By an ingenious device this contact-piece rolls over its contacts in place of sliding over them, thus reducing the friction to a minimum. At the same time, all moving parts have been kept very light, and the armature is pivoted on jewels, so that great sensitiveness is secured. The springs which counteract the electro-magnetic torque on the armature are adjustable by hand. To prevent hunting, a damper is provided in the shape of an aluminium disc which can rotate between the poles of a permanent magnet. This disc is driven by a small pinion in gear with a toothed sector connected to and moving with the armature already mentioned. As the gear ratio is high, the angular motion of the damper disc is many times that of the armature, and very effective damping is secured. The connection between the armature and the damper is of a flexible character, which introduces a little time lag between the motion of the two. Owing to this the armature can move a little ahead of its equilibrium position, to which it slowly returns as the pressure adjusts itself to the new conditions.

Some of the company's consumers demand an alternating-current supply, and to meet their requirements eight "static" sub-stations had been provided up to the end of 1916. They are fitted with oil-cooled transformers with an aggregate capacity at the date named of 1,800 k.v.a. The number of these sub-stations is to be considerably increased.

There are nine high-tension feeders supplying the rotary converters at the different sub-stations. The total length of these feeders is 49,000 m. Each feeder cable is of the three-core type, the cores having each a section of 70 sq. mm. They are paper insulated for service at 10,000 volts, and are lead covered and armoured with a double steel band. For the static sub-stations the feeders are of the same general type, but with a different section. Including these, the high-tension network is 597 km. long. The company's telephone service has necessitated the laying of 30.3 km. of cables.

For the low-tension continuous-current network single-cored paper insulated cables, lead covered and steel armoured, have been provided for the outers, but the neutral is in all cases a bare wire.

Of these cables, 235.3 km. had been laid up to the end of 1916, and there are in addition 822.3 km. of neutrals and distributing cables. In the main feeders the conductor section varies from 500 sq. mm. to 1,000 sq. mm., whilst the distributing cables have sections of from 35 sq. mm. up to 200 sq. mm. The corresponding neutrals have sections of from 30 per cent. to 50 per cent. of these figures. For the alternating distributing network 19.2 km. of cables had been laid up to the end of 1912, but this figure is being increased as rapidly as the conditions permit. In all, about 1,279 km. of cables of all kinds had been installed at the end of 1916, which has involved the opening of 3,082 km. of trenches.



THE NEW METAL, "BARIO."—According to *The Iron Age*, a new metal known by the registered name of "Bario" has been put upon the market by the Bario Metal Corporation, New York, as a heat and acid resisting material. The makers claim that this is the only commercial metal of its kind that does not rust, tarnish corrode or deteriorate. It is, they state, non-magnetic; it remains clear and bright, and is not attacked by sulphuric, nitric or muriatic acids, resembling in this respect gold and platinum. Its melting point is high, beginning at 3,100 deg. F., and increasing according to the grade of metal mixture used. It is manufactured in nine different grades.

CANADIAN STEEL OUTPUT.—With December estimated the steel output in Canada in 1917, as contrasted with that of the three previous years was as follows, in tons:

	1914.	1915.	1916.	1917.
Steel ingots	811,567	989,829	1,397,703	1,686,005
Direct castings ...	17,074	31,067	30,546	42,807
Total steel	828,641	1,020,896	1,428,249	1,728,812

The relative output of electric steel was as follows:

Electric steel ...	61	5,625	19,639	39,069

The total output of electric steel may prove to have been 45,000 tons last year when all data are compiled. The above figures are given in *The Iron Age*, New York.

THE INSTITUTE OF METALS.

In our last issue we recorded the proceedings at the meeting of the Institute of Metals, held on Wednesday the 13th inst, and we now proceed to deal with the meeting on Thursday, the 14th inst., when members assembled at 4 p.m. Four papers were on the programme for reading and discussion, but the fourth, "On Lead-Tin-Antimony Alloys," by Mr. O. Q. Ellis, M.Sc., was deferred until the evening meeting at 8 p.m.

The Constitution of Copper Rich Aluminium-Copper Alloys.

A paper bearing the title "The Constitution of the Copper Rich Aluminium Alloys," by Mr. J. Neill Greenwood, M.Sc., was first read in abstract by the author. We commenced the publication of this on page 277 *ante* and conclude it in this issue.

Professor C. A. Edwards opened the discussion and remarked that he was particularly interested in the experimental methods adopted by Mr. Greenwood. He could fully endorse the statements as to variations in Brinell hardness obtained with variation in the load applied. He pointed out that the load which it was necessary to apply in order to get what the author had described as a maximum hardness number had to be increased as the hardness was increased, and, as the author had mentioned, it was extremely difficult to know exactly what load should be applied. With a hardness of 100 Brinell, maximum value was soon reached—something of the order of 500 kg., but with a hardness of, say, 700 Brinell the true Brinell number could not be obtained below a load of some 5,000 kg. That was a defect of the method which had to be taken into account. He was also interested in the equations for the hardness-load curves given in the paper, inasmuch as they had nothing in common one with another. They showed the effect of cold working on the values obtained. If cold working could be eliminated a true intrinsic hardness value could be obtained, which should be followed by a common expression for the load-hardness number, which should be the same for all hardnesses, no matter what the material. The speaker had himself obtained certain results in this relation, but as they were to form part of a paper to be read by him before another society, he was not at liberty to speak much about them. He could say, however, that if, instead of using a slowly-applied static load an impact load were used, the diameter of the indent, no matter what the load, would equal constant times the fourth root of the energy applied. The equation—which he submitted, but not for publication—applied to all metals, whether lead or the hardest possible steel. It would be extremely useful if the author could expand his observations with regard to extrapolation, because, coupled with the equation, a true expression of the influence of cold working might so be obtained. To illustrate the effect of cold working, if tin and aluminium were tested by the Brinell and impact methods the tin, under impact test, would prove very much harder, but exactly the reverse under the Brinell test. This showed the difference in the capacity of the metals for cold working. The Brinell number obtained by slow application of the load could be calculated from the impact measurement. He held that the scleroscope methods of measurement were fundamentally wrong, the chief objection being that the height of the hammer was constant in all cases, so that the energy applied was always the same and the degree of work varied with different metals; of course the energy absorbed was different and the height of rebound, but this was not a true indication of the hardness of the material, although the true hardness value could be calculated from it.

Dr. Rosenhain, who spoke next, considered—as the author himself had apparently concluded—that it would have been better had the investigation began by limiting the phase fields more carefully and accurately than had yet been done. The property of hardness as measured hitherto did not, in the absence of the new methods now foreshadowed, appear to be the best method of studying the structural composition of complicated alloys. Electrical resistance or other methods would have offered a more definite set of results for limiting the phase fields. He regarded as a little premature the author's conclusion that the compound Cu_4Al did not exist by reason of the fact that there was no deflection in the hardness-composition curve. It was dangerous to generalise too widely from measurements of one particular physical property, even though the measurements were accurate and the physical property a well defined one. But in the present instance the measurements were not accurate and the physical property was one of the vaguest. Again the conclusion drawn that the distribution of constituents did not appear to have any effect on the hardness seemed at variance with experience and definite knowledge as to the behaviour of steel—these alloys being very similar to steel in their physical properties. If a pearlitic steel were so annealed that the pearlite structure was destroyed, a change would be produced in the Brinell hardness, with a decided lowering of the elastic limit. He would ask whether there was or was not a softening of the alloy due to the segregating effect of the annealing treatment, as measured by elastic limit. The author had referred to the gradual change in hardness which occurred with prolonged annealing in the case of certain of the alloys, when, apparently, the micro-structure had been rendered homogeneous, but the hardness continued to decrease by further annealing. The explanation given appeared to Dr. Rosenhain to be incomprehensible. It was stated that the result of the gradual diffusion of one constituent into the other was the formation of a supersaturated alpha solution. He believed that most physical chemists would agree that that effect would be the last which diffusion would produce. Did the author mean that after a prolonged heating, when homogeneity had been attained, there was still a change of constitution going on? Personally, he was inclined to think that the rearrangement of the crystals and the absorption of the amorphous inter-crystal layers, and possibly amorphous layers within the crystals, due to the rearrangement which diffusion brought with it, were responsible for reducing the hardness during the prolonged cooling which took place. He would suggest that interpretation was preferable to the one put forward. Mr. Greenwood had stated that "With regard to the second effect of quenching, namely, the retention in a state having a different volume from the stable state, this can only act in one way. That is to say, the greater the specific volume the lower the hardness value. This follows from the fact that the greater the distance between the molecules or molecular aggregates, the smaller the mutual attraction of the masses, the forces being inversely proportional to the square of the distances apart." Commenting on this, Dr. Rosenhain did not believe that Mr. Greenwood or anyone else was in a position to tell what the exact law of intermolecular attraction was—whether it varied inversely as the square or other power of the distance. When a metal was hardened by cold working its density was reduced, and a material that had acquired a lower specific volume, with the same chemical composition as before, would be harder and not softer.

Dr. Hudson was interested in the author's promise to bring forward, in the near future, the results of researches dealing with the constitution of the beta phase of the system. With regard to decrease of hardness owing to prolonged annealing, and Mr. Greenwood's explanation that this was due to completion of the diffusion of the beta in the alpha solutions, he did not think the proof conclusive; decrease of hardness was proved, but not that it should be attributed to want of homogeneity in the alpha solution. Etching was an extremely delicate means of showing slight differences in the composition of a solid solution. Had the author tried other methods of determining whether the alloys were micrographically homogeneous?

Professor T. Turner referred to the fact that the author regarded as negligible the effect on the Brinell test of coarseness of structure in the two constituents. This, presumably, was due to the size of the grains in the samples tested, since in every case different results were obtained. On annealing a sample of duplex brass and subjecting it to a Brinell test, the softer material received a rounded impression, while the harder had a smaller and rougher indentation. It was difficult to measure the true diameter of the impression, because measured in one direction it was longer than in the other. The Brinell test, in the case of duplex structures, would give different results with different portions. In Fig. 8 of the paper, the hardness curve was a straight line, a matter which was emphasised in Fig. 12; this must be exceptional, as the solid solution usually gave a curve. There were cases, also to be regarded as exceptional, in which the physical properties, say, reduction of area, might give a nearly straight line throughout the series. That was so with nickel steel; while the ultimate strength rose, the ductility fell very little. The dependence of the effect of cold working upon variations in the hardness of the material and the load used, was very interesting. Admirable as the Brinell test had proved, particularly with homogeneous mild steel, it was imperfect when the results obtained in soft and hard materials were compared.

Dr. Hatfield was the next speaker. He remarked, in relation to the circumstance, that the author had endeavoured to correlate the results of the Shore and Brinell tests, that his firm had obtained precisely the same results. He assumed that in drawing a line through the Shore results the authors had wished to show the relationship. Probably there was such a relationship, but other factors than tensile strength of the material would have to be taken into account to show this relationship. In connection with the Shore sclerescope, the physicist at his works had pointed out continued use of the instrument led to variation in the determinations, and careful investigation of the matter confirmed the physicist's statement. Had the author had a similar experience? [Dr. Hatfield, in reply to questions, stated that the hammer fell on different spots and was a diamond-pointed hammer.] In conclusion, the speaker considered that if the author could show, by tests depending on the elasticity or the true elastic limit, that with such coarse structures hardness did not actually increase, a great blow would have been dealt to the surface tension theory.

Mr. Greenwood then replied to the discussion. From what he knew of Professor Edwards' method of testing hardness he could not agree that cold-working effects were entirely eliminated; nor could he see how that could be brought about by any method of testing. There was nevertheless a way round the difficulty by taking a Brinell impression, then annealing the specimen, and taking a Brinell impression in the same hole. In this way the time would arrive when the area of the impression was just sufficient to support the load (the Brinell number represented pressure per square millimetre and the hardness number was load in kilogrammes divided by area of impression). On the question of the beta solution—the alloy of eutectoid composition being softer in the quenched than in the slowly cooled state, the curve he thought showed most of the alloys to be soft in the quenched state. He saw no reason for any connection between the hardness of the beta solution and of the corresponding alpha alloys. To Dr. Rosenhain he desired to say that the primary object of the work was to settle various points of difference between Professor Edwards and other people on the effect of quenching; that was why he was led to make hardness determinations. The question of the absence of Cu_4Al, referred to by Dr. Rosenhain, would have to remain open until further physical determinations were made. To the speaker it seemed highly probable that the compound was not present; it would be peculiar if a method of determination known to give definite types of hardness curve should not have done so in the case under discussion. With regard to the effect of segregation on the hardness, time had not permitted him to investigate the matter very closely. Dr. Hatfield had, however, asked for further information on the point, and he (the speaker) would endeavour to obtain it. His reason for his conclusion that the softening caused by annealing was due to the diffusion and ultimate break up of the beta constitution was this, that, on annealing alloys with the beta constituent, the latter disappeared, so that in the casting the microstructure consisted of

massive alpha, and embedded in it were small patches of eutectoid. He assumed that the only way in which the conversion into alpha could take place was by diffusion of aluminium through the areas. This the speaker proceeded to explain graphically on the blackboard. Dr. Rosenhain had referred to specific volume and the effect of cold working on the hardness. He could only reply that in each case where hardening occurred on cold working a definite, new modification appeared. In reply to Dr. Hudson, he had used persulphate of ammonia and other etching agents, but so far as he could now recollect he had been unable to detect any difference in the structure which accompanied the changes of hardness on prolonged annealing. With respect to Professor Turner's observations on the difficulty of measuring the Brinell impression in the case of large structures consisting of hard and soft materials, he would say that he had found no such relationship between the size of the Brinell impression and the harder constituent; the separate particles of the harder constituent were always considerably smaller than the Brinell impression; the size of the grain therefore would not affect the determination. The speaker concluded by saying that he would try to procure the information asked for, relating to Shore and Brinell numbers of the alloys consisting of constituents distributed in various ways.

A vote of thanks to the author was then proposed from the chair and passed by acclamation.

DIE-CASTING OF ALUMINIUM-BRONZE.

The next paper taken was one bearing the above title, the authors being Mr. H. Rix and Mr. H. Whitaker, M.Sc. This paper was read in abstract by Mr. Whitaker. It is reproduced in full on page 326 of this issue.

Mr. T. G. Hirst opened the discussion. He said that the little die-casting in aluminium which he had done afforded no results. He would be glad to know how the iron was taken up into the copper. His experience with an alloy containing copper showed, apparently, that, on melting, the copper sweated out of the alloy and left the iron in a spongy state; consequently small bright spots appeared in the finished chill casting.

Mr. F. Johnson referred to a paper he had read in 1916 before the British Foundrymen's Association, in Birmingham, on the subject of non-ferrous alloys in chill moulds, in which he had emphasised the importance of die-casting in non-ferrous alloys of brass. He had not, however, embraced the copper-aluminium alloys. In addition to the advantages of using aluminium alloys which had been pointed out in the paper, there was also the advantage that the aluminium present formed an external skin, preventing contact of the zinc of the brass and the iron of the mould. He saw no reason —as the authors had shown that cast-iron dies could be used—why brasses containing a small percentage of aluminium could not be made on a commercia scale. He would ask the authors if they had had experience with copper-aluminium alloys containing such high percentages as 10 per cent. or 15 per cent. of iron. Such alloys would be serviceable in connection with high temperatures. The authors had not, he thought, sufficiently insisted on measurement of fluid shrinkage as opposed to contraction in the solid. With regard to the influence of iron on the size of the crystals, a small quantity of iron would bring about a great refinement in the size of crystal. A correspondence on the subject of the difficulties of producing brass by die-casting appeared in *Machinery* some two or three years ago, one writer claiming that copper-tin alloys had been successfully produced, and Mr. Johnson would ask the authors if they considered there was any possibility of putting copper-tin alloys on the market in the form of die-castings.

Mr. Peakman, who was the next speaker, referred to his experience at the works of the British Westinghouse Company, where die-castings of all shapes and sizes were being made successfully. Turning to the paper, he would say that the shrinkage common in certain aluminium alloys with die-casting were largely due to the temperature to which the metal had been subjected in the crucible, to the temperature at which the metal was poured, and to the temperature of the die when the metal was poured into it. He noticed that the authors had confined their references to top-poured die-casting. In connection particularly with aluminium work this was important, preventing, as had been said, the contact of the metal with the die. On the other hand, feeding the dies at the bottom or side would eliminate many troubles. Was it not possible, also, to apply some outside pressure other than that given by the head of metal in the git of the die? The speaker believed that a reduction could be effected in blowholes, &c., by greater care at the crucible stage. The authors had indicated lines of research for the development of die-casting, and he would suggest a method of giving practical and commercial value to the information obtained. He would propose the making of a standard die, not of too intricate a design. Then certain metals should be experimented with, and also the material used in the die manufacture. There was room for investigation into the composition of the actual metal used for the die, particularly for the various portions. The Westinghouse Company had found the cast-iron die good, but the plugs used were of different material, and he rather wondered whether it would not pay to put on the die and the plugs a facing of some other material, backed up, it might be, with cast iron. The die must be made a commercial proposition, and he appreciated the paper from the standpoint of practicality.

Professor C. A. Edwards remarked that he had seen many of the castings referred to at the Westinghouse Company's works, and this interested him particularly in the paper. He believed the best die to use would be made of something other than cast iron. The material which he regarded most hopefully was that used for making the castings, as it had a protective coating of alumina which would preserve the mould from the action of liquid metal. It was certainly a mystery to know why iron should have such a beneficial effect in the production of die-castings. It must, however, be borne in mind that die-castings could be, and were being, made in the pure copper-aluminium alloys. The only explanation he would venture upon was that, in the case of the copper-iron alloys, the iron was the first element to crystallise and floated practically to the surface of the metal, preventing excessive oxidation and the formation of objectionable surface-filling alumina. There were certain details which should be observed in die-casting, such as casting from the lowest possible point of the mould and having as long a runner as possible; this always produced a scouring effect on the surface. Cast iron should not be used in making the alloys, but the purest wrought iron. Silicon being a fatal ingredient, the alloy should be melted at as low a temperature as possible, to avoid taking up silicon during melting. The authors, quite properly, had selected an alloy which gave the least trouble, but not necessarily the best results. In relation to these alloys, it was desirable to know the different properties that would exist in the different sections of the casting, since rate of cooling had an enormous influence on the latter. It was of no use to assume that in the casting as a whole certain mechanical properties would exist; in alpha beta alloys parts of the casting might differ entirely from others. He did not think, however, that manufacturers need hesitate to take the question up. Provided fairly simple cases were taken as a start and developments made on these, there appeared no reason why new manufacturers should not be able to make die-castings after a few weeks of experimenting.

Dr. Rosenhain, referring to the value of die-casting—the author's definition not being entirely correct—considered that there were definite advantages in die-casting apart from the question of production. One such advantage which die-casting had over sand casting was—the composition being the same—the greater strength, ductility and general superiority of the resulting material. With regard to the question of shrinkage, the authors were probably well aware that large quantities of articles in which strength and freedom from cracks were essential had been made—and put to excellent service—from chill moulds. Here he would remark that the 12 per cent. copper alloy was not remarkable for its strength; it was possible, at the high temperatures referred to in the paper, to get stronger alloys. The risk of cracking during cooling was considerable, but shrinkage could be overcome by stripping the die at the right moment. It was partly a question of experience, but could be assisted materially by accurate knowledge of the physical properties of the alloys at high temperatures. On the question of the action of iron, he was not prepared to say why, when the work of the Ninth Report to the Alloys Research Committee was undertaken, manganese was chosen in place of iron; perhaps for its deoxidising action, which might minimise the presence of alumina in the resulting alloy. The aim was to improve the soundness and casting properties. He had reason to believe that, in relation to the aluminium, the iron would be found to be present as the iron-aluminium compound $FeAl_3$. That compound crystallised out from its metallic solution at a very high temperature, somewhere about 1,400 deg. C.; by forming a sort of network through the whole body of the casting, it could materially resist shrinkage. In concluding his remarks, Dr. Rosenhain observed that the production of the castings was a remarkable achievement, and there was matter for congratulation in the policy which had enabled the authors to give a frank description of the methods and processes leading to such successful results. Finally, he referred to difficulty of soldering the aluminium-bronze castings.

Mr. Dewrance was the next speaker. He expressed some surprise that cast-iron for moulds should be so highly spoken of. Cast-iron was porous, and he had found that when the metal was poured in, it got into the pores, and often occasioned serious trouble. That might not be so much the case with the aluminium-bronze, but it certainly was with the tin-copper alloys. For that reason wrought iron was much to be preferred. In considering cost, moreover, the life of the chill was important, and this was affected by the changes which occurred in cast-iron after a certain amount of use. Such chills were apt to become distorted, and, for that reason, greater success had been attained in his foundry by the use of wrought-iron chills. The withdrawal of the internal portion was sometimes difficult to effect at the psychological moment; so much so, that, speaking from the engineering side, it was frequently preferred to machine out the internal portions rather than incur the risks involved in coreing them out. If the internal core were not withdrawn at the exact moment, there was a tendency to hidden flaws, which proved very troublesome when the article was finished. To prevent the metal from seizing or brazing the mould, it was necessary to protect the latter in some way or other, by the use of plumbago or other means. Although this course was less essential with the more fluid metals, he had found it requisite in the case of nearly all the metals he had used, even tin alloys. He appreciated the paper as likely to prompt further investigation on a subject of importance to members of the Institute.

Professor Carpenter asked the authors exactly how they effected the control of the pouring temperature of this alloy and what form of pyrometer they had found most suitable. With regard to the structure of the alloys, he desired to confirm all that Mr. Whitaker had said. Messrs. Corse and Comstock, who, he believed, were the first to work in copper-aluminium alloys—or, at least, to publish results—had submitted to the speaker photographs showing unmistakably that, up to a certain percentage of iron, the iron was dissolved in the alpha solution; above a certain point the iron came out in well-defined crystals. One result of the addition of iron was, undoubtedly, to diminish considerably the size of the crystals.

Mr. Whitaker, replying to the discussion, informed Mr. Hirst that the iron was put in as copper-aluminium-iron, 60 per cent. copper and 20 per cent. of each of the other constituents; it might, without detriment, have been put in as half and half, or even direct. To Mr. Johnson he would say that he and his colleague also had used an alloy containing a little aluminium, but had given it up in favour of aluminium-bronze, on account of the zinc attacking the die and producing a bad surface. On the

question of the percentage of iron, he would quote Corse and Comstock's conclusion that it was useless to add more than 6 per cent.; beyond that percentage there might be slight increases in ultimate strength and yield-point, but the ductility decreased to a low value. The speaker would take, for example, the case of an alloy containing 10 per cent. of aluminium and 8 per cent. of iron, in which the elongation was found to be 11 per cent. and the reduction of area 12 per cent. In answer to Mr. Peakman, numbers of the castings were bottom-fed castings, with the object of obtaining a better surface. The only objection was that it increased the scrap. Sometimes, moreover, it was less economical to aim at perfect surfaces straight away. The speaker illustrated, by the exhibition of castings of the "Butterfly" shape, his views on the subject of standard dies, remarking that he believed it possible to design a die which would afford a good idea of what would happen in the case of an intricate casting. The speaker had not tried a die made of aluminium-bronze, but, if possible, the experiment would be attempted and the results made known. The iron introduced into the alloy was wrought iron, not cast-iron; it consisted of small bits of iron which had been found, on analysis, to be extremely pure. Variation in strength of casting according to sectional area was a point of interest, particularly in relation to test bars. An inch test bar, cooled in air, gave 15 tons "yield" and 35 tons "ultimate." With ½-in. diameter bars made in the same way the authors obtained 20 "yield" and 50 "ultimate" and practically no elongation. In reply to Dr. Rosenhain, the term "die-casting" was used because the metallic mould itself was spoken of as a "die." He took the term "chill" to refer to the solid blocks of metal, such as used in casting iron, to produce local hardness. Dr. Rosenhain's account of the form in which iron existed in the alloy was of much interest. The high melting-point of $FeAl_3$ would indicate that it was the first constituent to crystallise out, confirming Corse and Comstock. The speaker believed it possible to solder aluminium-bronze by galvanising it first, and then soldering. In answer to Mr. Dewrance's inquiry as to protecting the mould, he had tried graphite, French chalk, Kieselguhr, and other things, but found no effective means of preventing molten zinc from attacking the die. Dealing with the president's question, no pyrometer had been employed; he believed that with accurate pyrometric control results would be consistent.

GRAIN SIZE.

The third paper on the programme was by Dr. G. H. Gulliver, F.R.S.E., and was entitled "On Grain Size."

This paper was not discussed in detail, being as Dr. Rosenhain pointed out, of too esoteric a character for discussion.

The meeting was then adjourned until 8 p.m.

(To be continued.)

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN.—MERSEYSIDE BRANCH.—Under the auspices of the Engineering and Shipbuilding Draughtsmen's Association, at the Ranelagh Hotel, Birkenhead, on the 14th instant an interesting paper entitled "Marine Condensers and their Design" was read by Mr. James Macauley. Mr. Macauley opened his lecture with a brief history of the condenser, and next dealt with the considerations controlling the design, and sub-divided these into five sections as under:—(1) Maximum amount of Steam to be condensed; (2) Minimum quantity of Cooling Water; (3) Minimum Cooling Surface possible; (4) Highest permissible temperature of hot-well; (5) Least possible absorption of power by the Circulating and Air Pumps. Each of these sections was then considered in detail.

LARGE HARBOUR CONSTRUCTION AT DRAMMEN.—The town of Drammen (Norway) has decided to expend a sum of 17,000,000 kronen upon extensions of its harbour. Ice often caused serious difficulties, and the inlet was both too shallow and too crooked. Under these circumstances it has been a serious matter to keep the harbour accessible during the winter months. The Svelvik stream has already been deepened and is now navigable for the largest vessel likely to enter the harbour, and considerable areas have been purchased, where the best conditions obtained for quay construction and the placing of rails in connection with the new inlet to the Drammen railway station. The new area will also be connected with Bragernäs, and the Lierdal can also be made to form part of the project, leaving plenty of scope for industrial expansion. The harbour basin proper will be formed of the main course of the Drammen River.

STANDARD CARGO SHIPS.*

By Sir GEORGE CARTER, K.B.E.

THE object of the paper is to place on record the advantages of standardisation in the construction of cargo vessels as a war measure, and to give some account of the work of the Advisory Committee on Merchant Shipbuilding in the design and construction of what are now known as "Standard Ships."

Towards the end of 1915 it was apparent that very great efforts would have to be made to provide sufficient cargo tonnage to supply the needs of the country. During this year and the following one (1916) the workers in shipyards had become very much reduced. Many men had left for the Army, and many others had been transferred to work in connection with the production of munitions of war. Apart from this, the demand for war vessels of all kinds was very great, and, above all, the demands for steel for war purposes increased to such an extent that the supplies available were inadequate. The many demands on the steel supply were all urgent, and it became exceedingly difficult to strike a fair balance between them. As far as shipbuilding was concerned steel for warships obtained priority, with the result that the supply for merchant ships was small and out of all proportion to the necessities of the case. The Board of Trade realised the position and strongly advocated the need for providing for the building of merchant ships, and, in conjunction with the Admiralty, some success was achieved, but far from sufficient to meet the increasing activities of enemy submarines. It soon became apparent that more drastic action was necessary. In December, 1916, the New Ministries and Secretaries Act was passed, which provided for the appointment of a Shipping Controller. The Act gave this Minister wide powers and provided that he should "take such steps as he thinks best for providing and maintaining an efficient supply of shipping." Sir Joseph Maclay became the Shipping Controller, and the Government decided at once that merchant shipbuilding should be under his control.

Merchant Shipbuilding Advisory Committee.—In December, 1916, after a conference with shipbuilders and marine engineers, Sir Joseph Maclay appointed the Merchant Shipbuilding Advisory Committee of which I had the honour to be Chairman. The first meeting of the Committee was held on December 20, 1916, and after fully considering the whole question it was decided, in collaboration with the Shipping Controller and his other advisers, to proceed at once with an extensive building programme of cargo ships of simple design and, as far as practicable, of standard types, both with respect to engines and hull. Although the Government's shipbuilding programme gave standardisation in shipbuilding concrete form on a large scale, standardisation had been widely discussed and urged as for practicable policy both in regard to hull and machinery, and had in fact taken definite shape on a smaller scale by individual firms adopting standard types of their own.

It will be as well at this stage to call attention to the great variety of merchant vessels that were under construction at this time. They totalled nearly 500, with an aggregate gross tonnage of over 1,800,000 tons. Amongst them were found fast and slow liners, intermediate passenger and cargo types, cargo boats built for special trades, fast cross-channel steamers, vessels built to carry special cargoes, "tramp" steamers, coasting vessels, and, in fact, all the varieties usually to be found in pre-war days. Even where the type were the same, individual vessels differed in size, speed, and arrangements. Many of them were built for special purposes, and practically all of them embodied ideas that were peculiar to particular owners and builders. Whilst many of these specialities undoubtedly served their purpose it is perhaps questionable whether a number of them were absolutely necessary. At any rate, since the standardisation of cargo ships has been introduced, it is generally conceded that much of it will continue to be practised even after shipbuilding and shipping conditions have again become normal, the reason being that in many ways economy of time, material, and labour are obtained by its adoption.

It can at once be stated that the greatest variations, both from the point of view of degree and number, were to be found in vessels carrying passengers. The need, however, for refinements of type, comfortable passenger accommodation, record passages, &c., had ceased to exist at the time of the appointment of the Advisory Committee. On the other hand, the need for plain cargo carriers, and plenty of them, was greater than ever it had been before. It was therefore decided that the vessels already under construction which fulfilled to some extent these latter conditions should proceed, and that standard ships should be constructed with all possible speed.

Standardisation.—The principle of standardisation having been accepted, it became necessary to design standard ships to meet the most urgent needs of the Shipping Controller. It was clearly desirable to limit the types as much as possible, but apart from the requirements of the Shipping Controller, the employment of the available facilities in the shipbuilding yards to the greatest advantage had to be considered. For this reason several different lengths were used for the ships, in order to use the greatest number of slips to their best advantage. Needless to say, the practical difficulties were great. No two yards had built identical vessels; each builder had his own special knowledge, his own particular type or types of vessels. Again, practice differed in different districts. The practice in one district was looked upon with disfavour in another. Shipowners, moreover, were anxious, quite naturally, to have their fleets kept up, and preferred vessels of the types similar to those built for them in pre-war days.

It has been said, that if builders had been allowed to proceed in their own way and to their own designs, that the output of ships would have been greater than it has been under standardisation. Such a contention will not bear examination when all the facts are considered impartially. There has undoubtedly been delay in the production of standard ships in spite of all the arrangements made to expedite their construction, the chief element being shortage of steel. If each builder had been allowed to proceed with his own type or types of ships, this delay would have been greater, as in addition to not getting the amount of steel required, the multitudinous sections necessary would have caused great delay in rolling at the steel mills, whose output was much increased by the simplification of sections in the standard ships, referred to later. It is not sufficient to compare the rate of production of standard ships with the pre-war rate of production. The limited supply of steel and other adverse conditions must be taken into account.

The argument that delay was caused by asking builders to construct a standard ship differing only slightly from their own type may have some justification in regard to one ship, but not to repeat ships, and it must not be forgotten that never before had a proposition been put forward to build an unlimited number of ships of similar types throughout all the yards. It is interesting also to note that in one yard a standard ship was completed in a little over six months, although the yard had never built a similar ship before. A second similar ship was also completed in practically the same time. In another yard a ship was completed, coaled, and sailed 18 days after launching. In spite, however, of all the difficulties and the diverse opinions held by responsible shipbuilders and engineers, the policy of building standard ships has been loyally accepted by them, and I think it may be claimed that as a war emergency measure the policy is being justified, and will in the future be justified to a much greater extent.

Advantages of Standardisation.—As the policy of building standard ships in bulk is a new one, it will not be without interest to put on record some of the advantages which are claimed for standardisation of this kind. They may be summarised as follows:—

1. The detail design for the type can be entrusted to a builder who is conversant with that class of vessel and whose duty it becomes to make the necessary calculations, prepare the specification and all the constructional drawings, for the information of other builders instructed to build vessels of the same type. Small

TABLE I.—PARTICULARS OF SHIPS ILLUSTRATED ON PAGE 308.

	Fig. 1. Type "A."	Fig. 2. Type "C."	Fig. 3. Type "D."	Fig. 4. Type "E."	Fig. 5. Type "Z."
Dimensions:—					
Length, between perpendiculars .. .. .. ft.	400	331	285	376	400
Breadth, moulded .. ..ft. in.	52	46.6	41.9	51.6	52
Depth, moulded .. ..ft. in.	31	25.6	21.2½	29	31
Displacement .. .. tons	11,375	7,200	4,750	9,910	11,400
Draught .. .. ft.	25.1	21.8	19	23.9	25.1
Block coefficient	0.762	0.760	0.732	0.749	0.762
Deadweight .. .. tons	8,175	5,050	2,980	7,020	8,000
Gross tonnage	5,030	3,000	2,300	4,400	5,800
Hull (steel) .. .. tons	2,225	1,390	1,110	1,920	—
Wood and Outfit .. .. tons	405	300	240	400	—
Engines (weight) .. .. tons	570	460	420	570	570
Light weight .. .. tons	3,200	2,150	1,770	2,890	3,400
Engines (single screw):—					
High-pressure cylinder .. .. in.	27	25	25	27	27
Intermediate-pressure cylinder .. .. .. in.	44	41	41	44	44
Low-pressure cylinder .. .. in.	73	68	68	73	73
Stroke .. .. in.	48	45	45	48	48
Boilers:—					
Number	3	3	2	3	3
Diameter .. ..ft. in.	15.6	14.0	16.6	15.6	15.6
Length .. ..ft. in.	11.6	11.6	11.9	11.6	11.6
Draught .. ..ft. in.	Howden	Howden	Howden	Howden	Howden

* Paper read at the Spring meetings of the fifty-ninth session of the Institution of Naval Architects, March 20, 1918.

details can, however, still be arranged in accordance with the ordinary practice of the individual builder.

2. The design being in the hands of one firm, all the steel scantlings after being settled in the ordinary manner can be carefully examined to reduce the number of steel sections in the ship as much as possible. This results in producing the fewest changes of rolls at the steel works and in the rolling of much larger parcels of material to the one pattern on account of the large number of ships that are to be built to this design. As an example of this, in the standard ships now built the number of sections are reduced to 8 or 10 as against 30 to 40 used in pre-war days for the same type of ships.

3. All the scrieve board work would be done by one yard giving full-size frame lines, beams, side keelsons, &c., copies of which can be supplied to the other firms concerned.

4. Steel-makers and builders can agree to divide the orders for material in accordance with the facilities of the steel-works, and having regard to proper times of delivery, so that the material first required is the first in order of delivery.

5. Whilst there is not the same difficulty with steel plates as with sections, arrangements for the proper order of delivery can be made.

6. With machinery the advantages of standardisation are probably more generally agreed upon, and more detailed attention is given to this in Appendix II. It may, however, be remarked here that the elaboration and production of design for auxiliary machinery and detailed fittings can be divided among the various makers, and each can arrange to undertake the whole manufacture of the details of a particular requirement. This does not by any means exhaust all the advantages of standardisation, for after these preliminaries have been settled many benefits arise during the construction of the ships and engines. The standard ships, although not all of the same type, have many features in common. For instance, similar sets of engines may be fitted in ships of different types, so that apart from the large number built of each type there is a still larger number into each of which a given set of engines can be placed. In the case of any one vessel and set of machinery built in the same yard, it may so happen that either hull or machinery will be completed some time ahead of the other. In such cases the machinery originally intended for one ship can be transferred to another, no matter where it is being built. These rearrangements are of great assistance in preventing, on the one hand, congestion of the engine works, and on the other, delay to vessels through machinery being behindhand. The auxiliaries and fittings including forgings and castings, being alike in vessels of each type, can be ordered in large numbers from the same maker and used in any ship or ships which may be ready to receive them.

Standard Ships.—Outline profiles and midship sections are given of some of the standard ships in Figs. 1 to 5, annexed, together with their principal dimensions and particulars on page 307. The general arrangement of the machinery as fitted is shown on page 309.

The first two designs made were the "A" and "B" types. Both these vessels are of the same dimensions, but the first is of the single-deck and the second of the two-deck type; their length is 400 ft., and deadweights 8,200 tons and 8,100 tons, respectively.

These types were followed by the "C" type, length 331 ft., and deadweight 5,050 tons, and the "D" type, length 285 ft., 2,980 tons deadweight.

The "C" and "D" types were laid down on the shorter berths as they became available, and later the "E" type was added so that the best use might be made of berths exceeding the "C" vessel's length, but under the "A" and "B" length; the "E" type is 376 ft. in length, and 7,020 tons deadweight.

For these five types of vessels two standard types of engines only were required. The "A," "B," and "E" vessels are all fitted with the standard "A" engines. The "C" and "D" vessels again have a type of engine common to both, although in the case of the "C" type additional boiler-power is provided.

To meet the urgent need for more oil carriers an important alteration was made later in the construction of a number of the "A" and "B" type vessels, through which, if the necessity arose, they could be completed as oilers.

In addition heavy oil carriers of 8,000 tons capacity known as the "Z" type are building. The overall dimensions of the "Z" vessels are the same as the "A" and "B"; the same standard type of engines are used as in the "A," "B," and "E" vessels.

All the types mentioned, except the "Z" oiler, were decided upon, the designs prepared, and details arranged while the Merchant Shipbuilding Advisory Committee was still meeting at the Ministry of Shipping, and other types were projected.

In designing the standard ships a point kept in view was the necessity for producing as quickly as possible plain cargo boats of the maximum carrying capacities with the least expenditure of material and labour, and of sizes most suitable to the majority of building berths and shipping conditions, &c. I feel that it is necessary to emphasise this statement because obviously the Government standard ships were designed to meet urgent war conditions. Whilst they might have a bearing on future standardisation, the question has not been dealt with from a peace standpoint.

The detailed design of each type in the first place was entrusted to a builder conversant with the class of vessel required and whose duty it was to carry out the work already mentioned. The engines were dealt with in a somewhat similar manner except that one Scotch and one English engineer used to the class of work collaborated on the one design and its details—these and the design of the ship afterwards meeting with the full

STANDARD CARGO SHIPS.

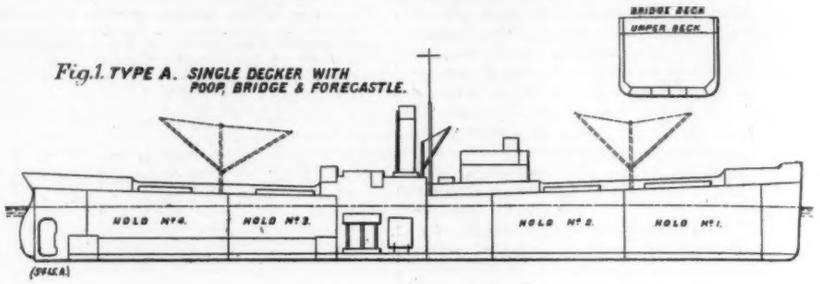


Fig.1. TYPE A. SINGLE DECKER WITH POOP, BRIDGE & FORECASTLE.

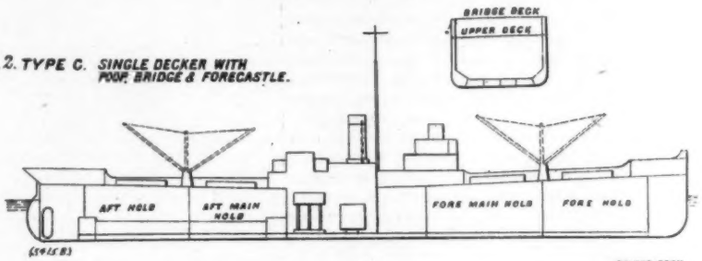


Fig.2. TYPE C. SINGLE DECKER WITH POOP, BRIDGE & FORECASTLE.

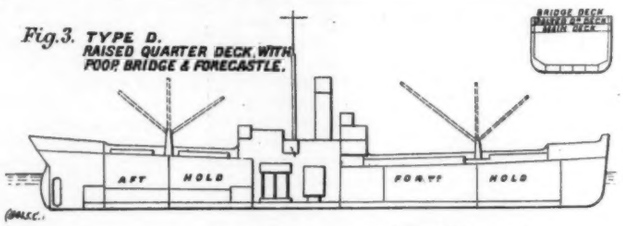


Fig.3. TYPE D. RAISED QUARTER DECK, WITH POOP, BRIDGE & FORECASTLE.

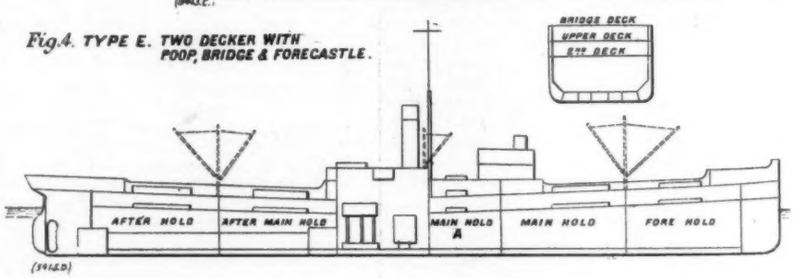


Fig.4. TYPE E. TWO DECKER WITH POOP, BRIDGE & FORECASTLE.

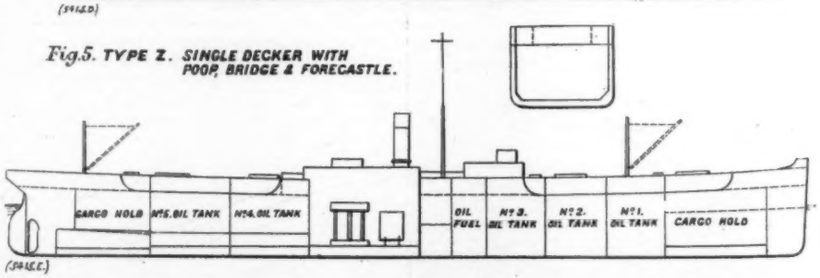


Fig.5. TYPE Z. SINGLE DECKER WITH POOP, BRIDGE & FORECASTLE.

assent of the Committee. It was arranged that the Classification Societies should concur in the various scantlings, and undertake, on behalf of the Ministry of Shipping, the entire supervision of the vessels during construction. Two surveyors of Lloyd's Register who had been associated with the Ministry of Munitions in the production of steel were assigned the duty of allocating the orders for steel material to the steel-works and of arranging for its distribution to the builders in conjunction with the Government officials as required. To facilitate the loading and discharging of cargoes large hatchways were arranged with an ample provision of derricks and winches. In the same connection the pillars were specially arranged as mentioned in Appendix I. Further points of detail are discussed in Appendix I. for the hull, and in Appendix II. for the machinery.

General Considerations. — As experience was gained with vessels already at sea which had received damage by mine or torpedo, it was only to be expected that modifications would be suggested. For this reason certain alterations were effected in the early standard ships after the plans were prepared. These were principally made on the advice of the anti-submarine authorities; but one other particular alteration is worthy of mention, in that greater safety and comfort is given to the crew by quartering them in the poop rather than in the forecastle, as was the usual practice before the war. It will be remembered that the Council of the Institution formed a Committee last year to consider the question of the effect of mine and torpedo explosions on the structure of merchant ships. The majority of the findings of this Committee, it will interest members to know, were embodied in the standard ships.

Certain precautions were taken to render the visibility of the standard ships as small as possible. Some of these can be mentioned, while others had better be left unnoticed. The derricks and derrick posts were made to hinge down, and there is only one mast for carrying the wireless aerials. This latter is partly telescopic and can be let down to the same level as the top of the funnel. The funnel is also made lower than usual.

Ordinary deck-houses were fitted, and these in conjunction with other outstanding features of the ship can be masked by those on board when desired by the use of arrangements provided.

The speed and horse-power of the standard vessels have purposely been omitted from this paper. There must be many to whom these particulars are familiar. Perhaps there are still some who think that the vessels should have been given greater speeds, although the speeds are somewhat higher than is usual for this type of

GENERAL ARRANGEMENT OF MACHINERY OF STANDARD CARGO SHIP.

Fig. 6.

GENERAL ARRANGEMENT OF MACHINERY.

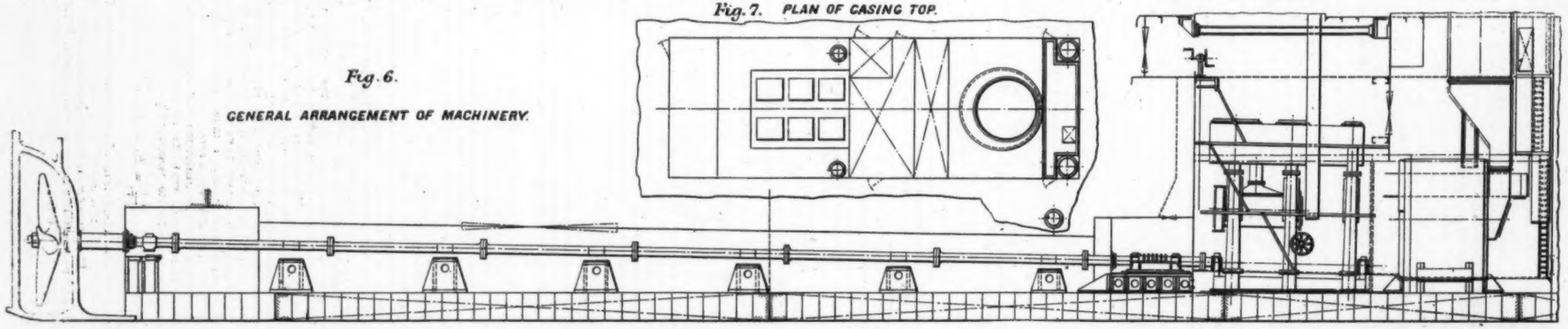


Fig. 7. PLAN OF CASING TOP.

Fig. 8. SECTION THROUGH ENGINE ROOM.

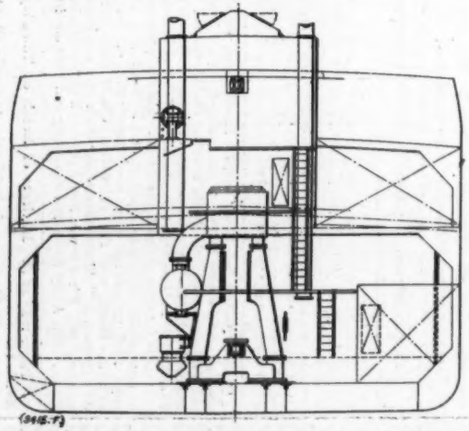


Fig. 9. SECTION THROUGH BOILER ROOM.

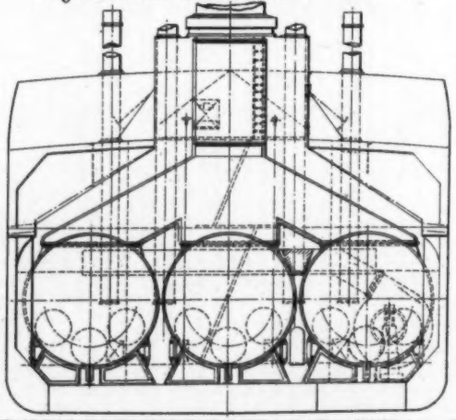
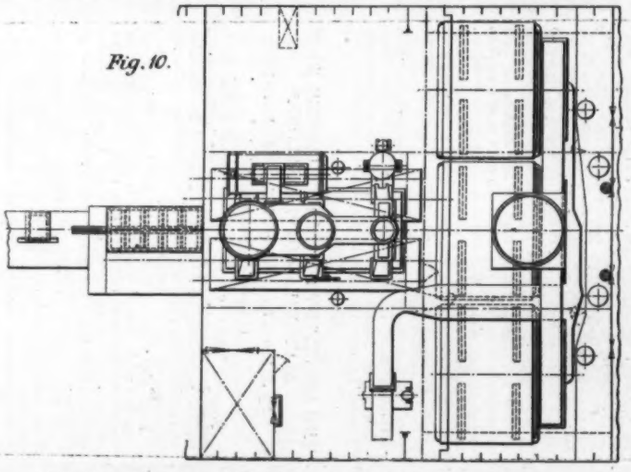


Fig. 10.



(34/5.7)

ship. The direct answer to this is that the actual speeds were concurred in by the Admiralty, who were in a position to know the requirements in that direction better than any one else. This was the guiding factor of the Committee, but it cannot be overlooked that increase of speed in any ship can only be obtained at great cost, and this is particularly the case in cargo ships of full form. Apart from this, at the time the standard ships were designed, consideration was given to the successful commercial use of these vessels after the war. Nevertheless, the great loss in cargo-carrying that would be entailed by fining up the lines, increasing the power of the engines, and the fuel that the vessel would have to carry, &c., must be considered when the question of speed is being viewed from all standpoints.

The bulkheads of the standard ships are discussed in Appendix I, but it may not be out of place here to refer to what are termed "unsinkable" ships. The word "unsinkable" must, of course, be used in a relative sense, because any ship can be sunk provided she receives a sufficient amount of damage. Advocates of unsinkable ships themselves usually specify that the word only applies to some definite amount of damage. Any responsible naval architect can design such an unsinkable ship, and actually many such designs were submitted to the Advisory Committee. There is one objection, however, which is common to all such types of vessels; in every case they require the expenditure of more steel per ton of deadweight carried. At the time the Advisory Committee was formed, as has already been indicated, steel was extremely scarce. Apart from this, all provisions for safety, if of an appreciable value, must complicate the cargo arrangements. Some curtail the amount of cargo carried, and all render it more difficult to handle the cargo. This, apart from increased steel required in construction and lengthened time of building, further limits the carrying capacity of the ship by increasing her time for loading and unloading.

Conclusion.—In May, 1917, the Department of the Controller of the Navy was formed and the work hitherto done by the Ministry of Shipping in connection with Merchant Shipbuilding was transferred to the new Department. The Merchant Shipbuilding Advisory Committee was also transferred, but shortly after this, for reasons which need not be stated here, the Committee resigned, and the Controller of the Navy immediately formed a Shipbuilding Council to assist him in regard to all matters respecting shipbuilding, both merchant and warship building and repairing. The members of the old Advisory Committee became members of this Council. Further types of standard ships have been evolved recently, but I do not propose to include them in this contribution. Enough has been said to illustrate the general principles involved. To introduce any general system of standardisation of ships would have been difficult in normal times, it is only to be expected that it has proved to be so even in the midst of the greatest war in history. On the other hand, the need having arisen so acutely, called for the attempt to be made. That criticism has arisen as to the Shipping Controller's policy, and the Advisory Committee's action, was only to be expected when one considers the eminent ship designers and shipowners who have special ideas and interests in the design of some ships already built, and the many ideas that have at one time or the other been proposed. That good results have, however, been attained will, I have no doubt, be generally conceded, and the appointment of a Committee to consider the general standardisation of Marine Engines is a sign that we may expect standardisation to play a definite part in the future. In post-war work we shall have to consider everything making for cheapness and rapidity of production, and standardisation will not be the least among such considerations.

APPENDIX I.

HULL DETAILS.

In all the vessels the longitudinal and transverse scantlings have been designed generally to comply with the standard of strength recommended by the Load Line Committee.

With a view to obtaining simplicity of construction, special consideration was given to the arrangement of the details of the structure, and it was decided to omit the ceiling on the tank top and the stringer on the ship's side, to fit only one keelson on each side in the double bottom, and to have large single angles at the upper and lower edges of the centre girder, suitable structural compensation or arrangements of equivalent strength being fitted in each case. The open bottom method of construction with solid floors on every third frame was adopted in the holds and boiler space, except in types "C" and "D," where on account of the probability of these vessels being engaged in carrying ore and coal cargoes, solid floors are fitted on every frame throughout.

To reduce labour and avoid the necessity of bending the main frame, brackets of extra depth are fitted on the tank margin, and no tumble home was given to the frames at the top sides. Only a centre row of pillars, reeled for shifting boards, was fitted (except for hatch side pillars in types "B" and "E"), and advantage was taken in several instances of the relative position of the hatchways and watertight bulkheads to support the deck by large brackets attached to the bulkheads

the holds being thus as free as possible from obstructions of any kind. To compensate for the absence of pillars at the sides of the hatchways, an arrangement of reinforced hatch-end beams and side coamings was adopted, the latter being also incorporated in the longitudinal strength of the ship in the way of the hatchways nearest amidships. In types "B" and "E," on account of the excessive depth required in the reinforced hatchways, side coamings and end beams at the second deck, when centre pillars only were fitted, it was decided to fit a pillar under each hatchway side coaming at the middle of the length of the hatch.

The officers and engineers, in accordance with the most recent practice, are berthed together in a large house at the fore end of the bridge deck.

Approximate flooding calculations were made for all types of the standard ships.

In vessels "A," "B," and "E," with the main bulkheads in the positions arranged by the builders, it was found that, by making the cross-bunker bulkhead watertight, the vessels would approximately comply with the "two-compartment" standard in way of the machinery space and cross bunker, and the "one-compartment" standard elsewhere. The position of the cross-bunker bulkhead was arranged in order to fulfil the above-mentioned conditions.

In vessel "C," in addition to the bunker bulkhead, an additional bulkhead was fitted in the after-hold, in order to comply with the same condition.

Among the detailed requirements, carried out in these ships which meet the findings of the Committee appointed by this Institution to inquire into the effects of mine and torpedo explosions, might be mentioned the following. No watertight door is fitted between the engine-room and the shaft tunnel, an access trunk being provided from the upper deck to the forward end of the tunnel. In addition, where watertight doors are fitted, they can be worked from an upper-deck position. Each suction-pipe, where it enters the compartment from which it drains, is provided with a screw-down non-return valve worked from the bulkhead deck.

APPENDIX II.

ENGINE DETAILS.

The details of the engine design are arranged so that the machinery is rather overdriven for war emergency measures; this policy was followed so that after the war the ships become fairly reasonable commercial propositions. For example, the "A" engine would in peace time probably run at about 80 per cent. of the power obtained from it at present.

As with the hull, all the designs, when settled as previously mentioned, with the exception of the auxiliary machines, were prepared by one firm and issued to the various machinery contractors complete, together with full detail specifications of all the raw material orders and the finished items which it was arranged to obtain from sub-contractors. The drawings and information issued contained quite an unusual amount of detail, so that firms not familiar with such work would have no difficulty in carrying it out.

The main engine design does not present any new features. There are, however, some outstanding details. The front columns which carry the astern piston-rod guides have been utilised as engine oil-tanks. The moving parts of the engine are of the simplest type, and every attention has been paid to facility for overhaul. The line shafting is all in interchangeable lengths. The reversing gear is of the all-round type, and a turning engine and gear is fitted at the after coupling. Ease of machining and assembling has been provided for in the arrangement and in the details, the piston type of valve for the medium pressure cylinder, for example, being adopted chiefly on that account. The centrifugal circulating pump is mounted with its engine on the main engine bed-plate, so that it can be fitted complete with its pipes and connections in the erecting shop.

Reference has been made in the paper to the advantages derivable from interchangeability, and examples of it have actually occurred. One firm, on discovering a defective sole-plate casting, had it replaced at once by a similar casting from another firm who did not require it at the time; this avoided a delay of several weeks in the erection of the engines. In another case a replaced main steam-pipe branch-piece was immediately dispatched to a vessel ready for her trial trip, the original one having shown leakage on the first steaming of the engine. Sub-contractors in particular were benefited by the multiple work, as they were enabled to proceed with a large number of each article instead of finding differences in small points of design as invariably occurs when the designs are prepared by independent firms or individuals. The principle of repetition in design was embodied everywhere. Small castings were ordered in multiple.

Apart from the advantage to the sub-contractors in carrying out repeat-work, small items in the engine-room which could be manufactured to better advantage by specialists rather than by large firms were ordered in large numbers for all the firms involved. This would not have been possible had they been different for each vessel. The orders for items such as auxiliary machine valves, valve-boxes, branch-pieces, cast and wrought-iron pipes, and so on, were issued in multiple from a single source by firms specialising in this work. For example, the mainsteam-pipes were finished complete by tube-makers, the drawings having been so designed that the unavoidable inaccuracies in fitting boilers and engines in place could be taken up at the joints, thus overcoming the delay which otherwise invariably occurs when pipes have to be made to fit after everything else is in position.

The auxiliary machinery was arranged so as to give the least work in completing the vessel after it was launched the various connecting-pipes being of the simplest form while providing all the usual coveniences for working. The feed filter and feed heater were embodied in a compact form in the engine hot-well, the feed-filter being easy of access. The winches exhaust to a winch-condenser in the engine-room, the size of which is ample to deal adequately with the winches when they are being used for a rapid discharge of cargo. The general service donkey and harbour-feed donkey are duplicates, and are capable of feeding the boilers in port or at sea. The use of copper piping was avoided as much as possible, and wrought iron was largely used in consequence, except for very small pipes. The result is that the weight of copper piping is less than one-sixth the usual amount in this class of vessel.

The boilers have been designed in accordance with well-established practice, and there is ample room allowed for cleaning purposes and for overhauling. Howden's forced draught is fitted in all cases.

THE CONSTITUTION OF THE COPPER RICH ALUMINIUM-COPPER ALLOYS.*

By J. NEILL GREENWOOD, M.Sc. (Manchester).

(*Concluded from page* 281.)

General Types of Hardness-Composition Curves.—Before proceeding with an account of the further experimental work on the Al-Cu alloys, it will be advisable to consider the possibilities which might arise in the hardness curves of binary alloys.

From the work of Kurnakow† and his collaborators, together with that of Guertler, it is possible to draw up certain simple and definite rules governing the types of hardness composition curves of binary systems. So far these rules are purely empirical; they are as follows:—

1. When two constituents, whether pure metals or solid solutions, form an eutectic (or eutectoid) structure, the hardness is a linear function of the composition, within the range in which the duplex structure is formed.

2. When a compound is formed in a series of alloys, and does not enter into solution with its components, the curve consists of two linear branches connecting the hardness of the compound with that of its two constituents. This system resolves itself into two of type (1).

3. When two components form an unbroken series of solid solutions (*i.e.*, are isomorphous), the hardness of each is increased by addition of the other, and therefore the hardness curve rises to a maximum at an intermediate composition.

4. If a compound is formed which is isomorphous with both components the hardness curve presents a minimum at the composition of the compound, rising to a maximum on either side, and falling to the hardness values of the respective components. The hardness of the compound may be, and often is, greater than that of either component, although occurring at a minimum (Fig. 7, p. 311).

From these general rules it is possible to construct hardness-composition curves for more complicated cases, but since these are only combinations of the above, it is not necessary to consider them in detail.

Before leaving this brief survey, attention must once more be called to the possibility of curvature occurring in those branches corresponding with eutectic structures. For, in conjunction with curvature of the "solid solution lines," it is quite possible that the boundary between two phase areas should be indistinguishable on the hardness-composition curve.

The Hardness of the α Solid Solutions.—With the exception of alloys 87 and 97, pieces 0.5 in. diameter and 0.5 in. thick were used for these tests. Below 8 per cent. Al the structure was not examined, as the work of Carpenter and Edwards, and of Curry, has shown that under no condition can these have a duplex structure. With higher percentages, however, the chill cast alloys are duplex, and so it was necessary to adopt the plan of continuous annealing at 600 deg. C. in the same manner as was described in a previous paragraph.

Ultimately the series of values given in Table XVIII was obtained for the Brinell and scleroscope hardness.

TABLE XVIII.—*Hardness of the α Solutions.*

Aluminium per Cent.	Brinell (1,500 Kg.).		Scleroscope.
Nil	5.85	50	—
1.5	5.80	51	9.0
2.5	5.70	54	10.5
4.5	5.55	57	12.0
6.1	5.39	61	13.5
8.1	5.20	65	15.0
8.7	5.16	67	19.5
9.7	4.86	76	—

These Brinell hardness values have been plotted against composition in Fig. 8 (the value for the 9.7 per cent. alloy would have fallen near to the curve had it been annealed for the same length of time as the alloys 81 and 87). It is seen that the hardness of the α solutions is a linear function of the composition. This is important in view of the fact that Carpenter and Edwards (*loc. cit.*, page 268) considered that the upper limit of the α solution range was the compound Cu_4Al containing 9.6 per cent. Al. The evidence on which this was based was twofold. First it was found that an alloy containing 9.6 per cent. Al by prolonged annealing and slow cooling could be obtained as an homogeneous solid solution. Secondly, by electrolysis of an alloy containing 10.7 per cent. Al, a residue was obtained which on analysis gave 9.6 per cent. Al. Neither of these tests is a criterion of the presence of a compound, for it might be a coincidence that the limiting solubility of the solid solution should occur at a composition corresponding with that of a compound. Curry (*loc. cit.*) does not consider that there is any evidence of the existence of a compound Cu_4Al. He places the upper limit of the α solution at 9 per cent. Al, and states that an alloy containing 9.5 per cent. annealed at any temperature is duplex.

The foregoing results, however, show that the upper limit of the solution is certainly not far from 9.7 per cent. Al, since an alloy of this composition was actually obtained as the simple α solution (micrograph No. 9, page 314), though great care had to be taken not to exceed 600 deg. C. in the annealing operation.

From the work of Kurnakow, of which a summary has already been given, it follows (rule 4) that if Cu_4Al forms the limit of the α series of solid solutions, then the hardness-composition curve should rise to a maximum between 4 per cent. and 5 per cent. Al, and then fall to a minimum at 9.6 per cent. Since there is no departure from a linear relationship, however, it can be said that the compound in question, although it may coincide with the composition of the upper limit of the α solutions, does not exist in this series.

The Hardness of the β Solutions.—Owing to the relatively small amount of work which has been published on the physical constants of solid solutions which are unstable at ordinary temperatures, it is difficult, if not impossible, to predict the hardness curve of such solutions from the equilibrium diagram. This uncertainty is brought about by the fact, that in order to obtain such solutions (under conditions which give strictly comparable results), it is necessary to rapidly cool the specimens from a temperature at which they exist in the hot stable state, so as to preserve this in the cold, or to make the tests at an elevated temperature (which in the present instance would need to be above 800 deg. C. in order to get a representative series, owing to the narrowing of the limits of the β solution at lower temperatures). As regards the latter method, the experimental difficulties have not yet been overcome sufficiently to make an accurate comparison. The former method, however, whilst opening up a large field for experiment, is limited from a theoretical point of view, owing to the unknown effect of the quenching operation on the hardness.

In quenched specimens it is quite possible that the hardness is made up of two components:—

(*a*) The actual hardness of the solid solution (when in state of perfect equilibrium), *i.e.*, the true hardness.

(*b*) A more or less complex factor due to the quenching.

It is on the nature of this complex factor that most, if not all, of the speculation and controversy on the effect of "suppression" of transformations on the hardness of alloys, has centred.

Broadly, it is recognised that the effects of suppressing a transformation by means of rapid cooling are as follows:—

1. A complex system of stresses is set up during the cooling, due to unequal contraction of different parts of the specimen. These will affect the still hot interior, and are most likely to be in the nature of compressive stresses on the centre. If the transformation is completely suppressed throughout the piece, these stresses will no longer exist when the specimen is cooled throughout, though there may still be effects. If, however, the transformation partially takes place—say near the centre of the piece—this will in general be accompanied by a volume change, and the piece will be in a state of strain in the cold.

2. The alloy is retained in a form which (generally) occupies a different volume from that of the stable state. Hence it is said that stresses arise due to the tendency to revert to the stable state and thereby occupy a different volume.

Besides these two generally accepted effects, Edwards (*loc. cit.*) considers that there is another due to the "suppression" of the heat of transformation, but this is not necessary. The quantity of this heat which remains latent in the quenched state depends upon the specific heats in the cold stable and hot stable states respectively.

Edwards says: "The act of quenching these alloys (steels) does in reality resolve itself into some form of energy is proved by the following reasoning:—

"With slow rate of cooling the γ solid solution decomposes into α iron and carbide of iron. This change . . . is accompanied by the evolution of a considerable amount of heat. With very quick cooling . . . the evolution of heat which would normally occur remains in the latent state in the quenched specimen. . . . The thermal change at 710 deg. C. . . . can only be prevented by the absorption of at least its equivalent amount of energy in one form or another, and since rapid quenching suppresses the Ar_1 (carbide change) the operation must constitute a force."

It can readily be shown, however, that this argument cannot be accepted without a knowledge of the specific heats in the two different states.

The latent heat of transformation from state B to state A is connected with the specific heats in these respective states by the relationship:

$$\frac{dq}{dT} = K_B - K_A$$

where q = latent heat of the transformation from B to A.

T = transformation temperature.

K_A and K_B = specific heats in state A and B respectively.

* Paper read at the Institute of Metals on Thursday, March 14.

† *Zeitschrift fur anorganische Chemie*, 54 (149); 60 (2); 64 (149).

Applying this to the case under consideration, and letting :

A = cold stable state,
B = hot stable state,
h_t = heat of transformation at the normal transition temperature,
h_{t-x} = heat of transformation at the suppressed transition temperature $t-x$;

then we have—

$$\frac{h_t - h_t - x}{x} = K_B - K_A.$$

In words, for every degree Centigrade lowering of the transformation from its normal temperature, the corresponding heat effect is decreased by the difference between the specific heat in the hot and cold stable states respectively. In the limit when $x = \frac{h_t}{K_B - K_A}$ we have $h_t - h_{t-x} = h_t$, and therefore $h_{t-x} = 0$. That is to say, when the temperature of transformation has been depressed by an amount equal to the ratio of the normal heat of transformation to the difference between the specific heats in the two states, then the heat evolution at this temperature will be zero. Hence it is seen to be unnecessary that the heat of transformation should remain latent in the rapidly cooled alloy, a part or the whole of it being given up as sensible heat during cooling, if the specific heat in the B state is greater than that in the A state.

It can safely be said that, in the majority of cases, the chief stresses set up by rapid cooling will be compressive. This follows from the fact that most metals and alloys have a positive coefficient of heat expansion, and hence the cooling must cause a contraction. Thus pressure is brought to bear on the alloy unequally in different directions due to variations in cooling velocity at the surface (except in the case of spherical pieces), and so deformation is possible. Hence although ultimately the interior portions will contract equally as much as the exterior portions (provided that both are retained in the same physicochemical state), they may have undergone profound internal rearrangement in order to bring about a more stable distribution of stresses whilst the latter were being applied. This disturbance of the crystalline arrangement is generally looked upon as the cause of the increased hardness of those alloys which are hardened by rapid cooling, *e.g.*, carbon steels and certain Al-Cu alloys. Thus Edwards (*loc. cit.*), and Edwards and Carpenter,* consider that this pressure gives rise to twinning of the metallic crystals, an operation which is considered as giving rise to amorphous metallic phase at the twinning planes.

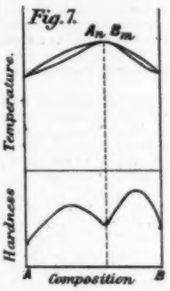
With regard to the second effect of quenching, namely, the retention in a state having a different volume from the stable state, this can only act in one way. That is to say, the greater the specific volume the lower the hardness value. This follows from the fact that the greater the distance between the molecules or molecular aggregates, the smaller the mutual attraction of the masses, the forces being inversely proportional to the square of the distances apart. It is obvious, of course, that many other factors might mask this effect, *e.g.*, the mutual attraction between two β molecular aggregates might be different from that between two α molecular aggregates. Since the tendency to revert to the stable state is at ordinary temperatures balanced by opposing forces, such as viscosity (in the case of steels and Al-Cu alloys at least), there seems little reason to suspect any increased molecular attraction (or hardness) due to this state. This remark refers to a completely suppressed transformation. If, however, the latter is only partially suppressed, but in such a way that the products are still so minutely distributed as to form a solution, it is quite possible that the molecular forces existing between the several different types of molecule would be quite different from those of either the hot or cold stable states. That is what McCance calls "interstrain," and its effect is obviously to cause an increase in hardness, for it brings about a state of affairs similar to that contained in rule (3), page 310.

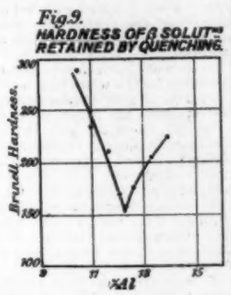
This summary of the possible effects of quenching is merely given in order to bring forward the great complexity of the considerations involved. Unfortunately, there seems, as yet, little hope of being able to separate the several causes and effects.

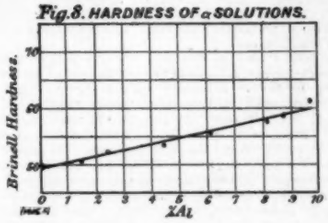
In the present work the hardness of the β Al-Cu alloys has been determined, using quenched specimens.

* Journal of the Iron and Steel Institute, 1914 (II).

As has already been shown, the hardness may be composed of two factors, and according to the relative magnitude of the two, it may or may not be possible to compare the experimental with the theoretical values (qualitatively). That is to say, if the "complex factor" is small compared with the true hardness, then the actual hardness may be taken as a measure of the latter.







Only Brinell tests are given for these experiments, as the scleroscope readings were very unsatisfactory. The results are given in Table XIX and are plotted in Fig. 9. Typical microstructures of the specimens after quenching are shown in Nos. 15 to 18, page 314.

The hardness curve is of peculiar interest, as it is of the type shown by a series of solid solutions containing a compound, Fig. 7. It is true that this type of curve would be expected if the hardness tests were made at a temperature at which the solution is stable. But that this should hold for the quenched solution is rather remarkable, especially in view of the previous ideas on the effect of quenching on these and other alloys.

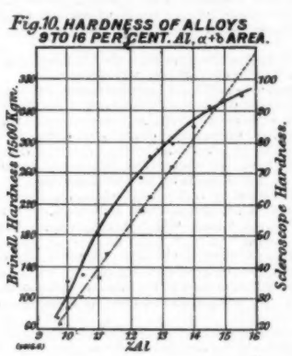
The alloy containing 10.5 per cent. Al is the lowest in the series in which it has been possible to retain the pure β solution. With the 10.0 per cent. Al alloy it was impossible to suppress completely the transformation even by taking the precautions mentioned above. Examination with a high-power objective always showed that a small quantity of α had separated along cleavage planes in the β solution.

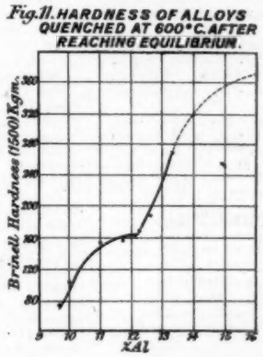
The hardness falls sharply down to a minimum in the neighbourhood of 12.3 per cent., and with higher percentages the curve again rises, though not so steeply.

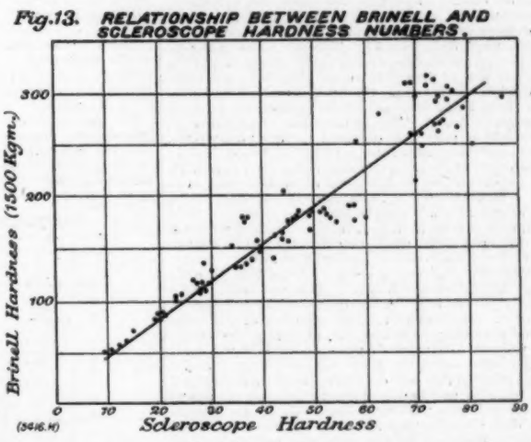
Unfortunately it has not been possible (so far) to obtain the pure β in specimens containing more than 14 per cent. Al, and even with this percentage it was almost as difficult as with the 10 per cent. alloy.

It has been pointed out that Edwards (*loc cit.*) considers that the quenching of the alloys brings about marked twinning of the β solution. That actual deformation does take place has been noticed throughout these quenching experiments, for whenever a smooth surface existed on the specimen the retention of the β was always accompanied by well-defined markings raised above the general level of the surface. From their general characteristics these markings probably correspond with those developed by etching the polished surface.

The only noteworthy feature of the series of microstructures is that between 10 per cent to 12 per cent. Al, the markings are in general not so broad or well defined as those in specimens containing more than 12 per cent.







The specimens used for these experiments were 0.5 in. diameter by 0.5 in. thick. It having been shown that quenching from any temperature, such that the particular alloy existed as the β solid solution, gave specimens of the same hardness, provided that the same physicochemical condition was retained, the actual quenching temperatures of most of these specimens were not recorded. The far more decisive criterion of examining the microstructures was used to check the efficiency of quenching. In no case was a hardness determination made unless the structure was that typical of the β solution.

It was soon recognised that the ease with which the various alloys (10 per cent. to 15 per cent.) could be retained as the β solid solution by quenching, varied enormously with the composition. Thus, although it was possible without any particular care to obtain 11 per cent. to 13 per cent. β solution with a 40-gramme specimen, it was exceedingly difficult to quench efficiently 10-gramme specimens containing about 10.5 per cent. and over 13.5 per cent. Al. Hence in these cases the size of specimen had to be reduced (0.5 in. diameter by 0.2 in. thick) in order to obtain satisfactory structures. Even then, care had to be taken not to heat the specimen higher than was necessary completely to transform it into β, and to increase the cooling rate by quenching in brine at — 15 deg. C.

TABLE XIX.—*Brinell Hardness of β Series Solid Solution.*

Aluminium per Cent.	Brinell Hardness (1,500 Kg.).		Remarks.
			Size of Specimen.
			in. in.
10.5	2.56	286	0.5 × 0.5
11.0	2.84	232	0.5 × 0.5
11.7	2.98	210	0.5 × 0.5
12.1	3.30	171	0.5 × 0.5
12.3	3.44	157	0.5 × 0.5
12.6	3.26	175	0.5 × 0.5
13.5	3.02	204	0.5 × 0.2
14.0	2.89	224	0.5 × 0.2

Nothing further will be said at present with regard to the hardness of the β solution, since experiments are now in progress which it is hoped will throw light on the nature of this, when retained by quenching.

The $\alpha + \delta$ Conglomerates.—This series of alloys exists between the extreme limits of 9.7 per cent. to 16.2 per cent. Al at normal temperatures. They result from the breaking down of the B solution at about 500 deg. C., and in general consist of an excess of (primary) α or δ, together with a greater or smaller quantity of the eutectoid. Since there is a very marked difference between the hardness of the two constituents, it would be expected that the hardness-composition curve would in this case depart from a straight line in accordance with the reasoning on page 310.

Since as the Al content increases from 9.7 per cent. to 12 per cent. the quantity of eutectoid *gradually* increases at the expense of the primary α, until at about 12 per cent. the whole alloy consists of the eutectoid, and afterwards the eutectoid is *gradually* replaced by primary δ, no sharp deviations of the curve are to be expected. [Andrew (*loc. cit.*) found that the hardness was constant for slowly cooled alloys above eutectoid composition. This requires confirmation.]

The specimens used were 0.5 in. diameter by 0.5 in. thick. They were heated up to between 900 deg. to 1,000 deg. C., kept there for an hour and cooled to 500 deg. C in two days. This treatment was given in order to allow the alloys to attain a reasonable state of equilibrium.

The surfaces were then ground and Brinell and scleroscope tests made.

The results are shown in Table XX, page 312, and plotted in Fig. 10. (Full line, Brinell curve, and broken line scleroscope curve.)

It will be noticed that the scleroscope curve is a straight line. Great difficulty was met in getting reliable figures with these small specimens, particular care being necessary that the two plane sides of the specimen were parallel. Even then it was found impossible to get reliable figures when the Al content was greater than 14 per cent.

TABLE XX.—*Hardness of a + δ Conglomerates.*

No.	Aluminium per Cent.	Hardness.		
		Scleroscope.	Brinell (1,500 Kg.).	
B	9.7	21.0	4.86	76
C	10.0	26.5	3.90	120
105	10.5	30.0	3.76	130
110	11.0	36.0	3.21	180
112	11.2	44.0	3.01	205
123	12.3	58.0	2.72	254
126	12.6	62.5	2.58	280
133	13.3	—	2.51	298
F	13.4	72.0	2.47	308
145	14.5	—	2.34	344
155	15.5	—	2.28	362

The Brinell curve is more interesting in that it exhibits the curvature mentioned on page 310, though in a different degree. It is obvious from the shape of the curve that the "extra" influence of the δ constituent comes into play almost with its appearance in the alloys. Hence we find that all the alloys above 10.5 per cent. Al are harder than corresponds to a linear relationship between hardness and composition, probably due to the mutual support offered by the two constituents in the eutectoid. It is also of interest because Andrew (*loc. cit.*) considers that the reason that the alloys containing less than 11 per cent. Al are softer in slow cooling than on quenching to retain the β solution is, that the soft nature of the α has a preponderating effect on the hardness determination. These results show that this is not so.

The structures of some of these α + δ alloys are shown on page 314. No. 10 shows alloy 100, the network being the eutectoid and the structureless part the α solution. In No. 11 is seen alloy 112, and it indicates a considerable increase in the quantity of eutectoid. Alloy 123, No. 12, shows that the eutectoid point has now been passed, for the thin dark boundaries, as also the small idiomorphic crystals, are the δ solid solution. It must be remembered that these crystals have been deposited from the β solution on cooling, and that therefore the symmetry which they present may be that of the β solution. Even better defined crystals are shown in the furnace-cooled alloy 133, page 314, No. 13. The increased quantity of the δ is very noticeable, as also is the thickening of the boundaries. No. 14 also shows alloy 133, but much more slowly cooled. In this case the δ has coalesced into large masses, there being no continuous boundaries such as those shown in No. 13. The beautiful laminated form of the eutectoid is also well depicted in this photograph. It is very interesting that there is practically no difference in the hardness of the structures shown in Nos. 13 and 14. This is important, as it has been contended that continuous boundaries of a hard constituent like the δ solution, especially when supported by a close eutectoid network, give a false hardness value. No better refutation of this contention could be given than this, for the respective Brinell hardnesses are 303 and 298.

The Hardness of Alloys Quenched at 600 deg. C, after attaining Equilibrium.—Between 9.7 per cent. and 12 per cent. Al the alloys when quenched at 600 deg. C. consist of the α an β solutions, the quantity of the latter increasing with the percentage of Al until the 12 per cent. alloy is pure β. Between 12 per cent. and 16 per cent. Al, on the other hand, the alloys consist of the β and δ solutions, the β in this case decreasing as the Al increases.

Before making any hardness determinations the alloys were subjected to a prolonged annealing in accordance with the data given on page 281 *ante*. All structures were examined in order to be sure that the quenching had been carried out efficiently before any tests were made.

The results of Brinell determinations are given in Table XXI.

TABLE XXI.

Aluminium per Cent.	Time Annealed at 600 Deg. C.	Structure.	Brinell (1,500 Kg.).	
	days			
9.7	13	α	4.86	76
10.0	14	α + β	4.23	101
11.0	12	α + β	3.61	140
11.7	12	α + β	3.48	150
12.1	12	β	3.40	160
12.3	12	β + δ	3.33	168
12.6	11	β + δ	3.15	187
13.3	11	β + δ	2.73	252

These values have been plotted in Fig. 11. It will be noticed that there is a marked deviation from a linear relationship between hardness and composition, just as in the case of the α + δ alloys. The 13.3 per cent. alloy was the highest on which this test was carried out, and the curve has been extrapolated beyond this, assuming the hardness of the pure δ alloy containing 16.0 per cent. Al to be 360, as found from the series of determination made on the α + δ alloys.

SUMMARY AND CONCLUSIONS.

The object of this investigation was to examine the relationships existing between hardness and composition in several phase areas at the copper end of the aluminium-copper equilibrium diagram.

Before this could be done satisfactorily it was necessary to make a preliminary examination of the methods which were to be subsequently employed. These included quenchings from different temperatures of alloys of various compositions, and determinations of the hardness of these specimens by the Brinell and scleroscope methods.

Accordingly the effect of various factors on the results obtained by these two instruments was first examined, and the information obtained may be summarised as follows :—

(*a*) With coarse structures consisting of two constituents of widely different hardness scleroscope tests must be made with great care, and the average of a large number of tests taken. The effect on the Brinell is negligible.

(*b*) For Brinell tests the specimens need not be thicker than 0.2 in. (if a load of 1,500 kg. is used), but with the scleroscope the results are erratic with this thickness, but are quite consistent with specimens of 0.4 in. and upwards.

(*c*) A wide variation in the smoothness of surface is allowable for the scleroscope tests.

(*d*) The Brinell hardness number increases with the load applied, but becomes comparatively constant with a load of 3,000 kg. and upwards. There is a linear relationship between the hardness as obtained with a load of 1,500 kg. and the corresponding hardness as obtained with a 3,000 kg. load, the latter being obtained by multiplying the former by 1.06.

A series of quenching experiments on alloys containing 8.7 per cent. to 13.3 per cent. Al was next done. These showed that the ease with which the β solution could be retained varied enormously with the composition, being easiest in the neighbourhood of the eutectoid point and more difficult as the limits of its existence were approached. The remarkable sluggishness of these alloys was also brought out by these experiments, and lead up to an inquiry into the time required for them to reach equilibrium.

It was found that at 600 deg. C. a period of twenty days was necessary for the phases to arrive at an equilibrium by means of diffusion. As a further result of these experiments it has been found that an alloy containing 9.7 per cent. Al can be obtained as the α solution. Hence the upper limit of the α solution range must be moved from the 9.0 per cent. as found by Curry to the neighbourhood of 9.7 per cent. as found by Carpenter and Edwards and the present author.

The hardness-composition curve of the α solutions is found to be linear, both by the Brinell and scleroscope. Hence the idea that the upper limit of this series of solid solutions is formed by the compound Cu_4Al cannot be held.

On the other hand, the existence in the β solutions of the compound Cu_3Al receives confirmation, from the presence of a minimum at the composition of the compound in the hardness-composition curve corresponding with this phase.

The alloys consisting of the α + β mixtures depart considerably from a linear relationship with the composition when hardness is measured by the Brinell method, in the sense that they are harder than would be calculated from a linear equation. The same remark applies to the α + β and β + δ mixtures.

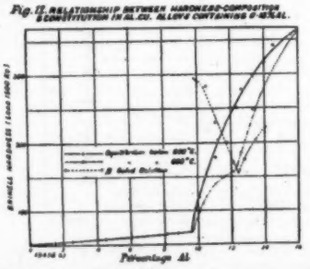


Fig. 12. RELATIONSHIP BETWEEN HARDNESS-COMPOSITION & CONSTITUTION IN ALCU. ALLOYS CONTAINING 0 TO 16 % AL.
Brinell Hardness (1500 Kg.)
Equilibrium Curve 600°C.
600°C.
β Solid Solution
Percentage Al.

In Fig. 12 the whole of the curves representing the relationships between hardness (Brinell) and composition in the phase areas considered, have been assembled, so that the relative hardnesses of different alloys, or of the same alloy with different heat treatments, can readily be ascertained. Further, by comparison with the microstructures, the changes of hardness with structure can readily be followed.

In conclusion, the author would like to point out that there are so many interesting points about the β solution that it has been necessary to make a separate investigation of it. Hence the almost total absence of theorising on this peculiarly tempting subject. It is hoped that the results will shortly be ready for publication.

APPENDIX.

RELATIONSHIPS BETWEEN BRINELL HARDNESS AND SCLEROSCOPE HARDNESS IN THESE ALLOYS.

At the commencement of this investigation it was the author's intention to use the scleroscope for the exploration of those phase areas in which the alloys were too brittle to stand even the lowest practicable Brinell load But after some experience had been gained in the usage of the instrument, it became apparent that the readings were unreliable after a hardness of about 50 had been attained. Accordingly it has been impossible to experiment on alloys containing more than 16 per cent. Al.

The results which have been obtained with the two types of instrument are plotted in Fig. 13, page 311, in which the ordinates are scleroscope hardness and the abscissæ Brinell (1,500 kg.) hardness numbers.

The very considerable deviations when the scleroscope hardness is greater than 50 is clearly shown. Even below this there are quite an appreciable number of observed points which fall off the mean curve. It has been noticed, however, that such points often belong to a definite series, *e.g.*, the series of specimens of alloy 10.0 per cent. Al quenched at different temperatures lay on a straight line lying above the mean.

EFFECT OF TORPEDO EXPLOSIONS ON THE STRUCTURE OF MERCHANT SHIPS.

SOME time ago the Council of the Institution of Naval Architects appointed a committee "To inquire into the effects of Explosions of Mines and Torpedoes on the Structure of Merchant Ships." The committee was constituted as follows : Mr. S. W. Barnaby (chairman), Admiral Sir Henry Jackson, G.C.B., F.R.S., *Professor Sir John Biles, D.Sc., LL.D., Mr. W. H. Whiting, C.B., Mr. A. E. Seaton, Professor T. B. Abell, M.Eng., Professor J. J. Welch, M.Sc., Mr. R. W. Dana, M.A., secretary.

Their first report is on cargo steamers and the second on passenger steamers, and they were submitted in May, 1917. They were made available privately to shipbuilders and shipowners ; but official sanction was given to their publication along with the annual report of the Council to this year's meeting of the Institution. We reproduce them here and comment upon them in our article on page 315.

I. CARGO SHIPS.

Your committee have thought it desirable to issue a preliminary report containing suggestions for certain temporary war expedients which might be adopted at very little expense in the ordinary type of cargo vessel, and which they are of opinion would have the effect of greatly increasing their chances of safety after being mined or torpedoed, provided that only one main compartment is opened up to the sea.

The committee, having examined the information placed at their disposal by the Admiralty and the Board of Trade, are of opinion that the loss of many of these vessels has been due to three causes : (*a*) the existence of watertight doors low down in the bulkheads which could not be closed after the explosion ; (*b*) Fractures of suction pipes in the attacked compartment permitting water to flow into adjacent compartments ; (*c*) The penetration of bulkheads adjacent to the attacked compartments by fragments of plating, frames, rivets, &c.

A large number of cargo vessels have four main holds and six bulkheads arranged as follows : No. 1, collision bulkhead ; No. 2, between Nos. 1 and 2 holds ; No. 3, at fore end of boiler-room ; No. 4, at aft end of engine-room ; No. 5, between Nos. 3 and 4 holds ; No. 6, at after peak.

With fewer bulkheads than this the chances of keeping a vessel afloat are very much reduced.

Taking this six-bulkhead arrangement as a typical case, the recommendations of the Committee, as applied to cargo ships with six or more bulkheads, are as follows :

1. All existing watertight doors low down in main bulkheads should be closed up and so secured that they cannot be opened. If watertight doors are necessary, they should be fitted high up in the bulkhead.

This is particularly important when bunker coal is carried forward of the boiler-room bulkhead, as a watertight door through which coal is being trimmed cannot be depended upon.

2. The watertight door to the shaft tunnel in the engine-room bulkhead should be closed up and so secured that it cannot be opened, access to the tunnel being provided by means of a watertight trunk carried up to the bulkhead deck.

Cases have occurred when the engine-room has been flooded too quickly to permit of the tunnel door being closed, with the result that considerable quantities of water have entered the after holds through the tunnel which was not sufficiently watertight.

An explosion in one of the after holds would be likely to injure the tunnel, resulting in the flooding of the engine-room and boiler-room, unless the tunnel door is closed as proposed.

3. The tunnel, or any other longitudinal passage below the water-line, should be thoroughly watertight.

4. Each suction pipe, where it enters the compartment from which it drains, should be provided with a screw-down non-return or other suitable valve, which can be worked from the bulkhead deck. These valves should be kept closed at all times, except when the pumps are in use.

5. The amount of injury which the bulkheads might receive from flying fragments will depend greatly on the nature and amount of cargo in the hold.

If the hold is well filled the risk of injury is much less then when partly filled or empty. If the cargo is of a heavy nature the upper parts of the bulkheads will probably be exposed.

It is recommended that, wherever possible, the bulkheads should be protected temporarily by means of timber or other suitable material, forming a splinter screen. In some cases the cargo itself could be utilised for this purpose. The necessity for some protection of this sort is particularly great in the case of ships in ballast.

Very little time and money would be expended in giving these measures of protection to a large number of cargo vessels.

II. EXISTING LARGE MAIL AND PASSENGER VESSELS.

These vessels having more numerous bulkheads in proportion to their length than the ordinary cargo steamer already reported on should be better able to withstand attack from mine or torpedo.

On the other hand, many mail and passenger steamers have watertight doors in the 'tween decks giving communication through the water-tight bulkheads between passenger and other spaces. They have also side scuttles, for ventilating cabins, and numerous sanitary discharges very near the water-line. These are liable to be submerged and to admit water should the scuttles

* Sir John Biles has been absent owing to illness since the first meeting of the committee.

be open or the controlling valves to the baths, water-closets, &c., be inefficient. This liability will be greater in the case of vessels having small initial stability or possessing longitudinal bulkheads, if damage occurs in way of such bulkheads. In some vessels also there are passages leading through bulkheads in the ship's hold to allow the firemen and greasers to gain their quarters without traversing any of the passenger decks. All these features have proved to be sources of danger.

Further, the hatchways in such vessels are relatively small and do not afford such instantaneous relief from air and gas pressure resulting from an explosion as in the case of the larger hatchways of cargo vessels. For this reason it is considered that bulkheads in the neighbourhood of the explosion are more liable to distortion in mail and passenger vessels than in cargo ships and that watertight doors on such bulkheads cannot be relied upon to close after an explosion. Devices for closing doors from the bridge are likely to fail, both by reason of the above-mentioned distortion and because of the probable destruction of the hydraulic or electric mains provided for the purpose in the region of the explosion.

In view of the foregoing it is suggested that the following measures be adopted in existing vessels during the continuance of the war :—

1. The disuse of all firemen's passages and the closing up of all doorways in bulkheads traversed by them when below the bulkhead deck, the firemen passing to and from their quarters by way of an upper deck, where a temporary screened passage could be provided if necessary.

2. All openings from the engine-room into shaft tunnels to be abolished and access to tunnels provided through trunks abaft the engine-room bulkhead : these trunks to be watertight to the bulkhead deck.

3. All watertight doors in transverse bulkheads throughout the machinery spaces to be closed and so secured that they cannot be opened, provision being made for efficient supervision in each separate compartment. If this is deemed impracticable in certain cases, it is recommended that in such cases the doors on the level of the stokehold and engine-room floors should be closed and others fitted as high up as possible on these bulkheads.

4. All watertight doors in transverse bulkheads on decks below the bulkhead deck to be closed and so secured that they cannot be opened, additional exits to the decks above being provided where necessary.

5. All side scuttles situated below the first deck above the bulkhead deck should be closed up and sealed. Special fan ventilation is to be provided if necessary for the cabins affected.

6. Each suction pipe where it enters the compartment from which it drains should be provided with a screw-down non-return or other suitable valve which can be worked from the bulkhead deck. These valves are to be kept closed except when the pumps are in use.

7. Where ventilation trunks, &c., pass through watertight bulkheads below the bulkhead deck, valves operated from above that deck should, in all cases, be fitted at the bulkheads, and if any trunk pierces the bulkhead at a low level it is strongly recommended that a new lead should be devised to carry it through the bulkhead at as high a level as possible.

8. Valves on all sanitary discharges at the ship's side should be such as will prevent water passing inboard through them when the vessel has considerable trim or list. These valves should be frequently examined and kept in good order.

9. Any ash or rubbish shoots, &c., having upper ends opening on decks below the bulkhead deck should be provided with watertight covers, and instructions should be issued to ensure that these covers are always in place when the shoots are not in use.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge all stand at 95*s.*, and for shipment to France and Italy these qualities are quoted 114*s.*; whilst No. 1 is 99*s.* for home use and 119*s.* for export to the Allies.

Hematite Iron.—Demand for East Coast hematite iron is unabated, but it is gratifying to learn that the situation is less stringent than it has been, and, in fact, there is now no real shortage for home use. Rather more iron is also available for shipment to the Allies. The position has been relieved by increased use of basic iron and scrap for the manufacture of steel. It is reported that in this district there are now some 20 furnaces producing iron for steel-making. It is also pleasing to hear of prospect of larger output of hematite at an early date. Nos. 1, 2 and 3 hematite still stand at 122*s.* 6*d.* for home use, and find a ready market for France and Italy at 142*s.* 6*d.*

Foreign Ore.—There is rather more business passing in foreign ore, and deliveries are much better, large cargoes against old contracts having arrived this week.

Coke.—Supply of coke is plentiful, but values are fully maintained. Home demand continues good, and there is an active market, but foreign trade is quieter. For home use average blast-furnace kind is 33*s.* at the ovens, low phosphorus sort 35*s.* 6*d.* at the ovens, and foundry quality 38*s.*; whilst for export both furnace and foundry descriptions stand at 45*s.* f.o.b., and gas-house product runs from 38*s.* to 40*s.* f.o.b.

Manufactured Iron and Steel.—Demand for all descriptions of finished iron and steel is unrelaxed. A strict control of distribution ensures good supplies to the shipyards where huge quantities of material are now being received. Government requirements also continue to take up a large proportion of the production. Fairly good shipments of shell steel are being made to the Allies. Prices are very stiff. To home customers common iron bars are 13*l.* 17*s.* 6*d.*; best bars, 14*l.* 5*s.*; best best bars, 14*l.* 12*s.* 6*d.*; iron ship plates, 15*l.*; iron ship angles, 13*l.* 15*s.*; packing iron and steel (parallel), 13*l.* 10*s.*; packing iron and steel (tapered), 15*l.* 15*s.*; steel bars (no test), 15*l.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel joist, 11*l.* 2*s.* 6*d.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.* There are no fixed prices for export, but approximately they may be given at 40*s.* to 50*s.* per ton above home quotations.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Work goes on apace in the steel-making establishments and, indeed, everything points to a very considerable increase of business in the near future, when, for instance, the better weather will enable more constructional work to be carried out in the shipyards. In the meantime there seems a slight lull in the demand for heavy ship plates and constructional material, but under existing circumstances there is little chance of this state of matters enduring for any lengthened period. Once again the idea of a scheme of "rationing" has been mooted, a suggestion having been made that this might be carried out on the basis of deliveries received in previous years. Something of the kind would be much appreciated by those most intimately concerned.

Malleable Iron Trade.—So fully are makers occupied with Government work, either directly or indirectly, that it is quite impossible for them to consider other claims. Every mill is kept running day and night unceasingly, for the national requirements are heavy and important, and likely to increase rather than to decrease, at least for some time to come, so that it is difficult to say when makers may be in a position to undertake the orders which would have been so gladly welcomed in former days when work was not always so plentiful or so easily obtained.

Scotch Pig Iron Trade.—No startling developments can be looked for in the Scotch pig iron trade, in the meantime production goes on in an intense degree. As soon as it is smelted everything is rapidly absorbed by the steel and iron works. So far as hematite is concerned, none is available for other than Government requirements. Export has dwindled to a minimum. Rates are firm and likely to remain so.

Clyde Workers' Wages Claims.—During a sitting in Glasgow, lasting for several days, the Committee on Production dealt with a number of interesting cases brought forward by, amongst others, the North-West Engineering Trades Employers' Association; the Boilermakers' Society; the Ship Constructors' and Shipwrights' Association; the Iron and Steel Trades' Federation, &c. A number of prominent Clyde firms and employers of labour were implicated in the labour disputes, and in all cases the decision of the committee was reserved. The members of the committee were Mr. W. W. Mackenzie, C.B.E., K.C.; Mr. George T. Rowe, and Mr. James Fullarton, Colonel J. M. Denny, C.B., taking the place of the last-named gentleman at the latter sittings.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—Admiralty collieries have been kept fairly well employed during the past week, but bituminous coals are weak, and particularly throughs, the bunker demand for which has necessarily declined. Bituminous smalls, and especially the better classes, are, however, comparatively scarce owing to the strength of the demand for coke. Steam smalls are a glut, and they continue to be stocked in increasing quantities. All washed coals are suffering from want of orders. Pitwood supplies are scarce, but the delay in the arrival of imported timber has not yet affected colliery working. Home-grown supplies are arriving in larger quantities, and the Allocation Committee is doing its work to general satisfaction.

Newport.—Employment in the Monmouthshire area continues irregular at the large collieries, but the smaller undertakings are working fairly full time. There is a surplus of all coals other than the better bituminous qualities, for which the coking demand is strong for blast-furnace requirements.

Pitwood Workers' Wages.—As the result of an inquiry conducted by a representative of the Ministry of Labour, an agreement has now been entered into regarding the wages of pitwood workers at the Bristol Channel ports. This is to the effect that the rate of wages as from March 14 shall not be less than 60 per cent. above the pre-war rates, but no reduction shall be made where the existing rates are higher than those indicated. A Central Wages Board is to be established within one month to which the labour organisations and the employers shall be attached for the purpose of dealing with wages questions generally.

Colliery Examiners' Dispute.—A settlement has now been effected of the long-standing dispute between the colliery examiners in the South Wales coalfield and the employers. The terms offered had been referred to the lodges, and at a delegate conference of examiners held at Cardiff on Monday, it was decided by an overwhelming majority to accept the terms of the proposed new agreement.

NOTICES OF MEETINGS.

PHYSICAL SOCIETY OF LONDON.—Friday, March 22, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, S.W., the fourth Guthrie lecture will be delivered by Professor J. C. McLennan, of the University of Toronto, on "The Origin of Spectra."

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, March 22, at 8 p.m., at 39, Victoria-street, Westminster. "Pyrometers and Impact Testing," by Mr. C. E. Foster.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, April 2, at 6 p.m., "The Storage of Bituminous Coal with Reference to its Liability to Spontaneous Combustion in Storage Heaps, Bunkers or Cargo" (illustrated by lantern slides), by Mr. J. H. Anderson (Member).

MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday, March 23, at the Grand Hotel, Manchester, the chair will be taken at 6.30 p.m. The Annual Meeting will be held, and a paper will be read by Mr. D. M. Caird (Member), on "Machine Forging."

SHIPBUILDING IN THE UNITED STATES.—The first triple launching on the Pacific Coast has been effected, three vessels, each of 9,400 tons, and of steel construction, taking the water a few days ago. In less than an hour, therefore, 28,200 tons were added to the nation's merchant marine. The vessels are each 425 ft. long, and they are the product of 4,000 men working day and night in eight-hour shifts.

HONOURS FOR NAVAL ENGINEERS.—The *Supplement to the London Gazette* dated the 16th inst., announces that the following honours have been awarded with the approval of H.M. the King, to members of the engineering branch of the Navy, among others :—For services in action on the occasion of the raid into the Straits of Dover by enemy destroyers on the night of February 14 and 15, 1918 : Engineer-Lieutenant John Abraham Kirkham, R.N.R., is to receive the Distinguished Service Cross; the Conspicuous Gallantry Medal is to be conferred upon Enginemen James Ewing, R.N.R., and Alex. Noble, R.N.R., and the Distinguished Service Medal is to be given to Enginemen Alex. Sandison, R.N.R. and J. H. Wakerley, R.N.R. His Majesty the King of Italy has conferred the following decorations :—Bronze Medal for Military Valour, Engineer-Lieutenant Samuel R. Baker, R.N., and Engineer Sub-Lieutenant Gerald W. Traylor; Engine-Room Artificers Edgar Hooper and A. G. Pedder; Enginemen C. F. N. Copland, R.N.R.; G. H. Dodds, R.N.R.; Alex. Fowler, R.N.R.; Herbert Gregson, R.N.R.; Ralph Haslam, R.N.R.; J. W. Siddle, R.N.R. and James Smith, R.N.R.

THE RÖNTGEN SOCIETY.—The question of the protection against X-rays, which has repeatedly been discussed by the Röntgen Society, was raised again at their meeting of March 5 by Drs. C. R. C. Lyster and Sydney Russ, in a paper on "A Biological Basis for Protection against X-Rays." They pointed out that devices which cut down the radiation to a certain small fraction, which differed for different apparatus, did not really afford protection, because the cumulative effects depended upon the amount of work done. Measurements might be based upon ionisation experiments made with electroscopes, or upon comparison of the tints which the rays produced on photographic plates; the photographic method was more convenient. Their plates were exposed to definite amounts of radiation from Coolidge tubes with various spark gaps to serve as standards. It was true that comparisons of deep tints (dark impressions on the films) were difficult, and that soft rays affected the photographic film more than hard rays; that was due to a secondary ray effect from the film. Their proposal was that operators should carry films about on their bodies to find out what depth of tint would go together with biological effects of the rays. It was acknowledged during the discussion that the protective lead-lined rubber gloves gave only a poor protection, that some people were more affected by the rays than others, and that dermatitis was not the only, and not the most serious, danger to guard against. Dr. G. W. C. Kaye, the president, suggested that the gloves should have a lining of some metal of low atomic weight to make the secondary radiation more harmless; he did not trust photographic methods, because the secondary ray effects from plates were complicated, but Dr. Russ replied that Barkla, to whose work he had especially referred, had found that ionisation in air was not free from eccentricities either. The "Mobile X-Ray Unit," which Mr. Howard C. Head then described, was not exhibited, as portable units had been in previous meetings, because the paper referred to the first automobile, a car carrying a complete X-ray outfit, which Messrs. Siemens Brothers had sent out to France during the war. The car had especially been designed by the Austin Motor Company to travel on rough roads and to be readily convertible into an operating tent. The chassis was low, so that all parts were at convenient height, and the car not likely to overturn; the drive was through bevel wheels from the benzine engine; the electric equipment comprised generator and 76 accumulator cells which could be coupled in five ways for working the apparatus and lamps; all the apparatus, comprising three current interrupters, &c., were fixed secure against vibrations, and yet easily removable for working in the tent or in some hospital; the X-ray room in the car was 12½ ft. long and 7 ft. wide, and there was a photographic dark room behind it; the complete car weighed 5 tons. Having described the outfit, Mr. Head showed with the aid of the kinematograph how the unit was being utilised.

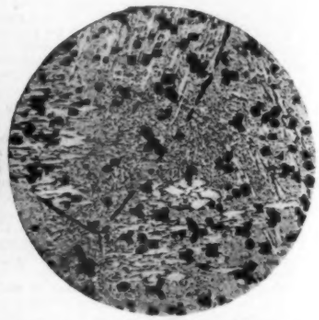
COPPER RICH ALUMINIUM-COPPER ALLOYS.

(*For Description, see Page* 310.)

No. 9.—Alloy 9.7% Al. Annealed at 600°C. for 13 days. Structure α. Brinell hardness, 76. Magnification 60 diameters.

No. 10.—Alloy 10% Al. Annealed at 600°C. for 13 days. Structure α + eutectoid. Magnification 60 diameters.

No. 11.—Alloy 11.2% Al. Very slowly cooled. Structure α + eutectoid. Brinell hardness, 205; Scleroscope hardness, 44. Magnification 60 diameters.



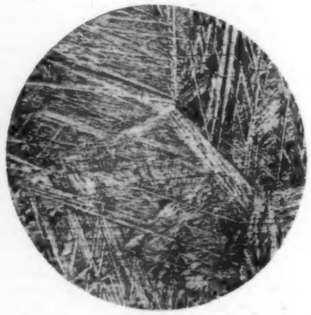
No. 12.—Alloy 12.3% Al. Very slowly cooled. Structure δ + eutectoid. Brinell hardness, 254; Scleroscope hardness, 58. Magnification 60 diameters.

Reduced by one-fifth.

No. 13.—Alloy 13·3% Al. Slowly cooled. Structure δ + eutectoid. Brinell hardness, 308. Magnification 120 diameters.

No. 14.—Alloy 13·3% Al. Very slowly cooled. Brinell hardness, 296. Magnification 120 diameters.

No. 15.—Alloy 10·5% Al W.Q. from β area. Brinell hardness, 286. Magnification 60 diameters.



No. 16.—Alloy 11·0% Al. W.Q. from β area. Brinell hardness, 292. Magnification 60 diameters.

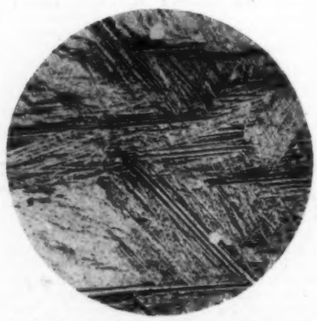
NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

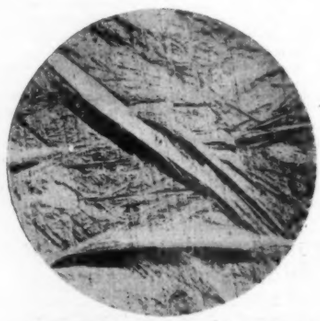
Sheffield Chamber of Commerce.—At the annual meeting of the Sheffield Chamber it was announced that Mr. Gregory Meakin, of the Nottingham Chamber of Commerce, had been selected from 150 applicants to fill the post of secretary. Mr. Peter MacGregor was re-appointed president. Sir Samuel Roberts, M.P., referring to reconstruction proposals said the Government were, he believed, proposing to make large advances to local authorities for the purpose of building construction, but in his opinion they would make a great mistake if in doing that they neglected private enterprise. All these schemes of reconstruction were as nothing to the question of winning the war.

Iron and Steel.—The steel and engineering branches have slackened off materially in many departments, and workpeople are being paid off. The loss, however, is largely compensated for by the increased activity in the aircraft and shipbuilding branches, where most of the discharged hands are finding employment. The women shell workers, whose services were recently dispensed with, are now engaged in the aircraft steel branches. Though less steel is going to the projectile works, there is little change so far in the pressure for deliveries. A large tonnage goes direct to ship construction in the shape of steel castings and forgings for machinery, files, pneumatic tools, engineers' small tools and tool steel. There is a considerable demand also for ship plates, and some of the Sheffield works which have hitherto been engaged on shell steel, have had their energies diverted into this channel. The output of pig-iron is fairly well maintained, though a shortage is still complained of in some departments. A difficulty which the iron makers are experiencing in common with other producers is that of securing adequate transport facilities. Stocks are actually said to be accumulating at some of the furnaces owing to the shortage of wagons to convey it to the consumers' works. Complaints are being received from makers of bars that the present maximum price of 13*l.* 17*s.* 6*d.* for common bars is unremunerative. The diminution of the shell output is causing anxiety in the scrap trade, the turnings from these departments forming a valuable addition to the limited quantity of pig-iron available. Export business is still shrinking, but this seems to have no effect on the numerous extensions which are taking place in the Sheffield works. Many of these are doubtless in view of after-the-war developments, but every month plans are being passed by the corporation for additions and improvements to works.

South Yorkshire Coal Trade.—All classes of manufacturing fuel maintain a heavy demand, and as the output is on a steadily declining grade owing to men being called up for army service, some difficulty is being experienced in securing deliveries of full contract supplies Steams of all sorts are in brisk request both for inland consumption and shipment, and prices firm at the maximum. A great portion of the shipment is for Government use, though a limited tonnage continues to be exported to France and Italy. There is practically no coal on the open market. The demand for gas fuel is well up to the average, and but little is passing into stock. Slacks are also a strong market. The supply of blast-furnace coke is limited, and deliveries much delayed. The requirements of the house coal market are being met. Quotations are as follows:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* to 14*s.* 6*d.*; seconds, 13*s.* to 13*s.* 6*d.*; smalls, 9*s.* to 10*s.*, per ton at the pit.



No. 17.—Alloy 12·6% Al. W.Q. from β area. Brinell hardness, 175. Magnification 60 diameters.



No. 18.—Alloy 14·0% Al. W.Q. from β area. Brinell hardness, 224. Magnification 60 diameters.

ELECTRIC REVERSING ROLLING MILL: ERRATUM.—We learn that the flywheel of the rolling-mill gear described on page 282 of our last issue is a casting, not a forging as stated. The reference to Figs. 5 and 7, column 3, line 17, from top, should be to Fig. 6.

PERSONAL.—G. A. Harvey and Co. (London), Limited, Greenwich Metal Works, Woolwich Road, S.E. 7, inform us that in order to facilitate the carrying out of important contracts they have opened a City Office at Suffolk House, 5, Laurence Pountney Hill, E.C. 4.—The Government having commandeered the offices in India House, Kingsway, of the Paterson Engineering Company, Ltd., and also the temporary offices they took at Windsor House, Kingsway, the company's address for the duration of the war will be 11, Southampton Row, W.C. 1. Their new telephone number is Museum 4630.—S. Dixon and Son, Limited (Leeds), have removed their London Offices from Kingsway House, Kingsway, W.C. 2, to Walter House, 418-422, Strand, W.C. 2, owing to the commandeering of the Kingsway premises by the Government.—The announcement which has appeared in several English newspapers to the effect that the Fiat Company has established new steel works in Austria is calculated to give the impression that the leading Italian motor-car company is interested in industrial development in an enemy country. We are therefore requested to state that there is no connection between the Fiat Company of Turin, Italy, and the Fiat Werke, of Vienna.—The London office of Messrs. Hans Renold, Limited, of Manchester, is being moved to Bush-lane Chambers, Cannon-street E.C. 4, owing to the fact that the Air Board is taking over their premises in Kingsway.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

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"ENGINEERING" may be ordered from any newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£2 9 0
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Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8596 GERRARD.

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NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 313.

ENGINEERING.

FRIDAY, MARCH 22, 1918.

MERCHANT SHIP DESIGN AND TORPEDO ATTACK.

WE are glad that the Admiralty and the Board of Trade have given their consent to the publication of the report of the committee appointed by the Council of the Institution of Naval Architects to inquire into the effects of explosions of mines and torpedoes on the structure of merchant ships. This report, which appears on page 312, was issued as a confidential paper so long ago as May of last year, and the principal recommendations were embodied in a notice to shipowners and masters circulated by the Board of Trade in June. It is perhaps to be regretted that the Admiralty and Board of Trade have not made the adoption of these recommendations of the council compulsory, in view of the importance attached to them by a very competent committee after the examination of a large amount of evidence of damage suffered by torpedoed merchant ships, and the personal inspection of numerous vessels under repair. The form in which the weekly returns of torpedoed ships are issued by the Admiralty makes it impossible to judge whether a larger proportion of ships which have been successfully torpedoed have remained afloat since the issue of the confidential report, because such vessels are not included in the returns, but it is only too evident that a very large number still fail to do so. If the Council of the Institution of Naval Architects are correct in their belief that the adoption of a few simple precautions would result in the saving of a large proportion of the vessels which are being sunk, it is of the utmost national importance that their advice should not be disregarded.

So long as merchant ships were unarmed nothing short of a complete system of convoy could prevent them from being sunk by submarines. Single vessels could be overhauled by a fast U-boat running on the surface, and sunk either by gunfire or by bombs placed on board without the expenditure of a single Whitehead torpedo, and the most perfect subdivision would have failed to save them. But as soon as they were armed the case was altered. The U-boat could no longer overhaul them as her submerged speed was insufficient to enable her to do so, and she was compelled to attack with the torpedo. It is impossible to provide a convoy for every vessel, and if by any means the ship can be enabled to survive the blow of a single torpedo an important object will have been achieved. No doubt in some cases the submarine would discharge a second torpedo in order to complete the destruction of the ship, but it should be remembered that there is always the chance of assistance arriving in time to prevent this, or the submarine may have exhausted her necessarily meagre supply, and in any case, if she is forced to expend two torpedoes on each ship instead of one, the number of vessels she has it in her power to sink is at once reduced by half.

When the council decided to appoint their committee there were many who believed that the structure of a merchant ship could not be expected to withstand torpedo attack; that the shattering effect of a modern Whitehead was such as to destroy the watertightness over large areas of the shell plating extending beyond the watertight compartment attacked, and that in all probability the dynamic effect of the sea entering through very large holes carried away the bulkheads. The committee's investigations disposed of both these theories. It was found possible to establish the maximum size of the hole made by the torpedo and to prove that the riveting of the hull within a few feet of the edge of the hole was not disturbed. In no case has a bulkhead constructed according to Lloyd's rules been found to have given way from water pressure alone. They found that in a large majority of cases the loss of the ship was due to the flooding of compartments outside the injured area from causes which were easily preventable.

Very many merchant ships carry coal in a reserve bunker forward of the boiler-room in addition to that carried in side bunkers in the boiler-room. This reserve bunker is partitioned off from the cargo hold by a non-watertight bulkhead. The reserve coal is used during the outward voyage, being worked through watertight doors in the forward boiler-room bulkhead. On the return voyage the reserve bunker is used for cargo. If the vessel is torpedoed either in the engine or boiler-room, or in the hold containing the reserve coal while the coaling doors are open, the probability is that the vessel will sink. There is very little hope that these doors could ever be closed after an explosion, as it has been shown that they are liable to be immediately choked with coal washed out of the bunker. Indisputable evidence was found by the committee of the danger of using these reserve bunkers at sea, and they recommend that the watertight coaling doors should be permanently closed and so secured that they cannot be opened while at sea.

They found that the second cause of the loss of many vessels is the watertight door in the engine-room bulkhead leading to the shaft tunnel. This door is usually provided with means for closing from the upper engine-room platform, but cases have been investigated in which an explosion in a hold abaft the engine-room has destroyed the tunnel, resulting in the immediate flooding of the engine and boiler rooms. Even if there were time to close the door from the platform it has been found that portions of the cargo are washed under the door and prevent its closing. In one such case inspected the ship only owed her safety to the fortunate circumstance that the reserve bunker was not in use at the time and, therefore, the flooding did not extend further forward than the boiler-room. There have been cases where water has entered the after holds through a leaky tunnel when the engine-room was flooded. When it is remembered that the flooding of the engine-room usually plunges the ship into darkness the danger of depending on the closing of doors is apparent. The council, therefore, recommended that doors to the shaft tunnel should be permanently closed and access provided to the tunnel through a watertight trunk abaft the engine-room bulkhead. This involves a little more trouble to the greaser on his periodical visits to the tunnel, but should be unhesitatingly insisted upon by the Board of Trade during the continuance of the war.

Another danger lies in the main drain pipes leading from the bilge pumps to the different compartments and passing through all the watertight bulkheads. These pipes are generally found fractured in the torpedoed compartment, with the result that water flows into other uninjured compartments. All that is required to prevent this is the provision of non-return valves on the ends of these pipes. One other precaution is all that is considered necessary to give the ordinary merchant ship a very good chance of safety. This is to protect the bulkheads as far as possible from flying splinters. Although a ship may have her bulkheads spaced as closely as is required to secure her safety in case of any two adjacent compartments being thrown open to the sea, there is risk of the bulkheads at each end of a torpedoed compartment being

penetrated by flying splinters which might cause the loss of the ship through the filling of three adjacent compartments. They therefore recommend that wherever possible the bulkhead should be protected temporarily by means of timber or other suitable material forming a splinter screen. When the holds are full the cargo itself affords protection, and by careful stowing the best advantage can be taken of this.

As compared with the cost of making good the loss of a dozen or more large vessels a week, the cost of carrying out these three or four simple requirements is negligible.

The second part of the report deals with "Existing large mail and passenger vessels." There is no doubt that the public have been greatly disappointed and dismayed at the readiness with which vessels of this type, although of the largest size and latest construction have gone to the bottom when struck by a torpedo. Representing as they do the best examples of the naval architects' and builders' skill they were expected to be able to survive the explosion of a mine or torpedo in any part of their structure. It is not surprising that people have asked themselves whether there can be anything wrong in the principles which have guided naval architects in the provision of the necessary buoyancy, and stability to preserve the safety of the ship under apparently the very circumstances in which she has found herself, namely, with one or two compartments open to the sea. There is nothing wrong in the principles. Ships can be made safe, but that they are not safe now is shown by the terrible regularity with which, after a longer or shorter interval, the loss of the ship follows the explosion. The fault does not lie with the naval architect.

The fact is that, as the chairman of the committee has pointed out, startling as the statement may appear, large passenger ships are not divided into watertight compartments, but into compartments which are capable of being made watertight. For the convenience of the passengers and crew nearly all the watertight bulkheads are pierced by doors most of which are normally open, but which are intended to be closed on emergency. Many of the latest and best ships are provided with means for closing all watertight doors simultaneously from the bridge and under pre-war conditions when the danger was principally from collision there would usually be time to make use of these appliances, thus completing the subdivision of the vessel. Even if the doors were not closed actually before a collision took place, the bow of the striking ship might be expected to stop the hole for a short time and so give an opportunity to close them before much water enters. But in the case of a torpedo explosion such an enormous hole is opened instantaneously that there is no time at all for closing doors. The council point out that an explosion which wrecks a compartment is likely to destroy the mechanism of any system of bridge control, and also to distort the neighbouring bulkheads, and thus prevent the doors from being closed. Moreover, collisions are of rare occurrence, and usually take place in foggy weather when special precautions could be taken, whereas the torpedo danger is ever present. The report calls for the closing up of all doors in transverse bulkheads below the bulkhead deck and for the provision of additional exits to the decks where necessary. In fact, during the continuance of the war, instead of waiting until after the blow falls before the ship is properly subdivided, she should never be allowed to be caught in any other condition.

One of the largest and most splendidly-equipped vessels employed as a hospital ship sank by reason of an excessive list and change of trim forward following an explosion, which brought the lower deck side-scuttles under water. These were open for ventilation, and water poured in through one after another in succession. Hence the recommendation that all scuttles below a certain height above the water-line should be permanently closed, artificial ventilation being provided where necessary. Particular attention is directed by the report to the danger arising from the existence in many of the largest mail steamers of tunnels connecting the boiler rooms with the firemen's quarters forward so that these men may get about the ship without passing through any parts where passengers may be. Such tunnels give away the whole security of the ship and ensure her rapid foundering if the opinion of the council is correct that the provision for closing watertight doors in them cannot be depended upon. At least two cases have occurred in which vessels fitted as hospital ships have sunk after reaching shallow water, due to water entering the ship through baths, wash basins, W.Cs., pantry sinks, &c. These vessels would otherwise have remained afloat. As it was, their salvage was only due to their having been torpedoed near a port.

All the recommendations of the council are intended to have effect only during the continuance of the war. The owners of one line of large passenger steamers have carried out the whole of the recommendations of the committee for an expenditure on each vessel of considerably less than half the cost of a single Whitehead torpedo, and the work was done while the ships were in port between voyages without interference with their time tables. It is probable that in some ships a greater expenditure would be necessary, but in view of the importance of endeavouring to save vessels rather than to build them faster than the enemy can sink them we do not think it could be more than would be justified.

ENLIGHTENMENT ON THE SHIPPING SITUATION.

THIS has been a week of enlightenment on the shipping situation, and no apology is necessary for the amount of space we are devoting to the subject in this issue. There are, however, dark patches on which further light is desirable, and we hope that the grave error of the past in not taking the nation, and particularly the working classes, into full confidence will be borne in mind, because there is nothing like a full consciousness of the gravity of the situation for the stimulation of the workers. The one feature which will have unqualified approval is the appointment of Lord Pirrie as the Controller-General of Merchant Shipbuilding. The choice is admirable, and still more important and commendable is the decision that Lord Pirrie should, although not a member of the Board of Admiralty, be responsible only to the First Lord, and have access to the Prime Minister and the War Cabinet when he feels that the interests of merchant shipbuilding require consultation with the highest authority and the Government. We could have wished for an equally decisive treatment of the labour difficulty associated with merchant shipbuilding. Sir Eric Geddes refused, in his long statement in the House on Wednesday, to enter upon this question. This is to be regretted, because the Earl of Durham, in his Presidential Address at the Institution of Naval Architects, made it clear that Government interference in this question has had serious effect in merchant shipbuilding production. In our leading article last week we entered fully into this question, and need only say again that all that has been brought to light since then has confirmed our view that the multiplicity of labour departments, with conflicting ideas brought into practice in the same establishment, has militated seriously against that amicable relationship between employers and men which would assist, if allowed more fully and freely, to find a solution by mutual effort.

The defence of the Admiralty policy by the First Lord in the House of Commons, and by the Controller, Sir Alan Anderson, at the Institution of Naval Architects, was satisfactory so far as it went. While we learn with satisfaction of the amount of work that has been done, there is room for doubt as to whether the maximum has been achieved. What is necessary for peace is that the output of merchant tonnage available not only for war transport work, but for the supply of food and raw material for munition and other production, shall be, at the earliest possible moment, equal to the loss of merchant tonnage available for such purposes; and, still more important, that the date shall be hastened when the supply of tonnage shall exceed the wastage. For the first time we have had definite information regarding the output of tonnage as well as the loss. Sir Alan Anderson stated that last year was a record year in the output of tonnage, including merchant and fighting ships. Sir Eric Geddes stated that the output of tonnage and ammunition, of all calibres of guns, was in 1917 not far short of twice that of 1916; that the output of aeroplanes was two and a half times that of 1916; and that arrangements for labour and material to secure still greater output this year were in progress during the later months of 1917. In addition to turning out a record total of merchant and warship tonnage we have multiplied by ten times the number of naval craft repaired and refitted, and in six months we have increased the merchant ship repair tonnage by 80 per cent., or an increase of 237,000 tons per week. Notwithstanding all these great expansions of work in many directions, and notwithstanding the growing demand upon the man-power of the country, as regards new merchant tonnage output, we entered the year 1918 with an output of 419,621 tons for the last quarter of 1917, as against 213,332 tons for the last quarter of 1916. This was done, moreover, with a dislocated industry, with yards only gradually being cleared of unfinished work, and with large numbers of unskilled *personnel* in the yards.

Although the loss by submarines is on a consistently declining scale, while the construction of enemy submarines is on a steadily increasing scale, we have got to consider that for the first three years of the war little was done in connection with merchant shipbuilding. In the fourth quarter of 1914, the merchant tonnage produced in the United Kingdom was 422,320 tons. This steadily fell; and it must be noted it was concurrent with the commencement of our great munition effort, until the fourth quarter of 1915, when it reached 92,712 tons. It then began to rise, and the rise is as follows: Quarterly, 1916—first, 95,566 tons; second, 107,693 tons; third, 124,961 tons; fourth, 213,332 tons; and in 1917, first quarter, 246,239 tons; second, 249,331 tons; third, 248,283 tons; and 419,621 tons in the last quarter of last year. Contemporaneously the output of tonnage in the allied and neutral countries has shown a corresponding reduction. Thus, the total tonnage produced, even in last year, when effort was being accelerated, was far below the normal output in merchant tonnage. This is the more serious as we learn for the first time the tonnage losses by German submarine attack. For the twelve months of unrestricted submarine warfare the world's losses (excluding enemy) were 6,623,623 tons, though the enemy claimed 9,500,000 tons. The net reduction in the world's tonnage since August, 1914, is only 2,632,297 tons, the difference being due to vessels built, enemy ships taken over, &c. Thus the proportion of net loss to the tonnage afloat is comparatively small—about 8 per cent., but it must again be enforced that only a small part of merchant shipping is available for the transport of food and raw supplies. The British, of course, have lost more severely from torpedo attack due to the concentration of German effort against our trade, and to the fact that our ships trade most extensively works within the danger zone. Our net losses are 20 per cent. To reduce the point to a common factor it will be necessary, in order that the supply of new tonnage will equal the wastage, that our output must be increased by over 100,000 tons per month, which demands the best possible organisation, the least possible interference in labour affairs, and an increase in the number of skilled workers to be withdrawn from the army to supplement labour. Sir Eric gave the assurance that everything would be done to accelerate this accession to the ranks of the workers.

The criticism of the merchant shipbuilding department of the Admiralty was met not only by the contribution to the Institution of Naval Architects, and by the speeches of Sir Alan Anderson and Sir Eustace d'Eyncourt, but also by the First Lord in his speech in the House. We quite agree that time was necessary to get the standard scheme in full operation, and that now that it is in operation, under the stimulating and experienced guidance of Lord Pirrie, good results will accrue. But, as one speaker put it, it is important that there shall be the absolute minimum of change in design, so that repeat ships can be produced with all the advantages accruing to repetition work. Sir Eric Geddes, like Sir George Carter, made a good case for changes

which had been made in design. The latter gave some of the principle reasons for the changes in design in ships. They are, increased speed to evade submarine attack on certain routes; hinged masts or abolition of a mast to prevent enemy submarines from ascertaining the course of a ship; alteration in the position of the mast and funnel for the same reason; alteration in the shape of the bridge, eliminating straight lines and angles for the same reason; alterations to provide additional gun mountings and for heavy gun mountings and accommodation for gun crews owing to increase of submarine warfare; conversion to oilers owing to disproportionate loss of tank tonnage. There are two other principal reasons of alteration: First, to provide additional space for the crews and better conditions for them. Second, to simplify designs to meet views put forward by the builders themselves. The First Lord also gave some particulars regarding fabricated ships, and showed that comparing this type "N" with the type "A" described in Sir George Carter's paper, we get 2,470 tons additional deadweight capacity for an extra 11½ ft. in length. Each net ton of steel in the new type will carry 4.06 tons deadweight against 3.53 tons in the "A" type, an increase in carrying capacity of 15 per cent. for each ton of steel.

The First Lord has issued a white paper on the subject, and has promised to issue quarterly returns of the ships launched as well as of the ships sunk, the latter being slightly in arrear. We contended for such a return in our leader last week, but not a quarterly return. The interval is far too long, and will fail to stimulate the shipyard workers. What is necessary to achieve this end is a weekly return, so that the workers will realise the immediate need for their effort. We have no objection to the losses being slightly in arrear, but strongly commend the need and importance of statements at the shortest possible intervals.

PROBLEMS IN ATOMIC STRUCTURE.

On Saturday afternoon last, at the Royal Institution, Sir J. J. Thomson, O.M., P.R.S., delivered the fifth lecture of his course on the above subject.

In opening his discourse the speaker said that on the last occasion he had suggested that spectra might possibly originate by an electron falling from one position of equilibrium inside the atom to another. In this fall a finite amount of energy was liberated. The idea brought forward as to how this event arose was that the disturbance to which the atom was subjected altered the repulsive force represented by the term $\frac{Ae}{r^3}$ in the law proposed for the interaction of a positive and a negative charge. The disturbance was assumed to increase the repulsion and the electron was accordingly displaced to a new position of equilibrium further away from the nucleus. One of the hypothetical Q particles was then suddenly ejected and the electron fell in, and in doing so gave out a unit of radiation, which carried away with it a definite amount of energy, equivalent to that which the electron had gained in falling from the one place to the other. On this view, all radiation was built up of definite units, so that light itself had a molecular structure.

If this were the case, the question arose as to how these units acquired the regularity of phase actually observed in optics. It was not enough that the units of light should have the same periodicity, but there must also be a continuity of phase as they passed through transparent media. This continuity of phase was particularly notable in Michelson's experiments on long-distance interference. His results appeared, however, to be not due to any action in the system emitting the radiation, but to the action of the medium through which the radiation passed.

Newton, in his corpuscular theory of light, which bore a good deal of resemblance in its fundamentals to modern views, had suggested that his corpuscles were subject to alternating fits of easy transmission and of easy reflexion, so that it was almost a matter of chance whether one of his particles on encountering a molecule was reflected or transmitted.

It was of interest to determine how such a property as that assumed by Newton could be established in the case of the electric systems of which it appeared the atoms and molecules were constituted. What would be the effect of rapid changes of phase on these systems as the units of radiation came up? When light passed through a transparent medium, this medium was itself affected. The electrical systems comprised in it were thrown into forced vibrations, with a period (that of the light unit) differing from their natural period. If the elements of light were uniform in phase these forced vibrations settled down, and there was no loss of energy. If, however, the phase of the light was irregular, there would be a period of disturbance before this stage was attained, during which the medium would emit light of its own periodicity, and there would be a corresponding dissipation of the energy of the incident light. Light of variable phase was accordingly easily absorbed, the loss being far greater than when the phase was continuous. Units in the proper phase would, on the other hand, get through the medium without much loss of energy. The medium, therefore, exerted a sorting action on the units which reached it, making them come into step. In this way uniformity of phase would be impressed on the light units even should these be emitted almost at haphazard.

Fig. 1.

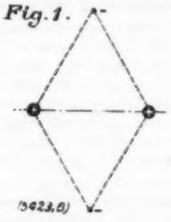


Fig. 2.

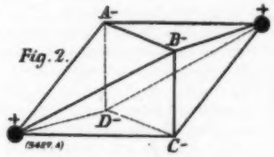
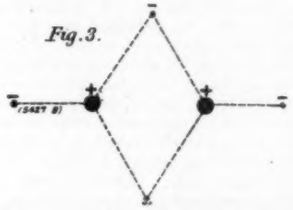


Fig. 3.



The view above advanced as to the origin of radiation implied that an electron might have more than one possible position of equilibrium inside the atom. If in the case of hydrogen, for instance, there were two such positions, we should have two different kinds of hydrogen atom. With the electron far out, the refractive index would be greater than when the electron was closer to the nucleus, and it would, moreover, be easier to extract an electron from the outer position of equilibrium than from the inner one, and there would thus be two ionising potentials. There was, however, no evidence in normal hydrogen of the existence of these two kinds of hydrogen atom. If, however, the matter were considered more closely, it would be noted that the special state corresponding to the far-out position of the electron was itself supposed to be produced by the same cause as that which produced the light; and this special state was therefore not a normal one. It was only when hydrogen was in a state ready to emit light that the abnormal atom was to be found; and it was noteworthy that when hydrogen was self-luminous it had some special properties, certain absorption lines being then apparent which could not be detected in the normal condition of the gas. The fact that we could not separate normal hydrogen into two kinds did not accordingly constitute an argument against the views advanced.

The shortest wave-length in a spectrum was that associated with the greatest energy. The emission of light of this wave-length corresponded to the fall of an electron to that point of equilibrium which lay nearest the nucleus. There was thus on this view a limit to the frequency of the light emitted by H and, in fact, such a limit was indicated by Balmer's series, which converged to a value of $\lambda = 3646$ Å. This was the limit of the most conspicuous series in the hydrogen spectrum.

Schumann had, however, discovered a new kind of radiation of much smaller wave-length than ordinary, and this discovery had been developed by Lyman, who had found that hydrogen was capable of emitting radiations with a wave-length of between 800 Å and 900 Å, or only one-quarter of the limit of Balmer's series. Hence, if the spectra originated as suggested, the Balmer series was not produced by the fall of the electron to the absolute minimum of distance from the nucleus; and it must be possible for this electron to get nearer to the centre than it ever did when producing the lines of Balmer's series.

In the foregoing it had been assumed that light was produced by the sudden transfer of an electron from one position of equilibrium inside an atom to another, and it was of interest to inquire whether a change of the same sort might not occur in the case of compound molecules.

In a previous lecture* he had suggested that the hydrogen molecule consisted of two positive nuclei bound together in stable equilibrium by electrons as indicated in Fig. 1. Suppose now that two atoms, each containing two electrons, formed a molecule, then there were a number of possible alternative positions for the two additional electrons. The arrangement might be, for example, as indicated in Fig. 2, with the electrons at the points A, B, C, D. In another alternative, probably more stable, the square A, B, C, D would be replaced by a triangle, one electron being at the centre of this and the other three at the corners. Still another alternative was represented in Fig. 3, where the additional electrons lay outside of the positive charges instead of between them. With all the electrons between the positive nuclei we had a representation of what chemists called double bonding, whilst with two of the electrons outside the bonding was single. If the electrons swung round from the system of bonding represented in Fig. 3 to that in Fig. 2 there would be a definite change of energy. From a mechanical point of view, the effect was much the same as when an electron changed its position inside an atom, and we might expect an emission of light. Hence, if we subjected a molecule to any process which altered the bonds between the atoms, we might get radiation, and this radiation would not be accompanied by the actual ejection of an electron. There would thus be no ionisation and no conductivity. Light might thus be produced by merely altering the arrangement of the chemical bonds.

It was possible also to account in this way for certain remarkable changes in the colour of certain compounds which occurred without any detectable change in the chemical composition. Fluorescence also might be due to the existence of two isomeric compounds differing only in the linkages by which the atoms were united. The fluorescent light would be emitted in the change from one system to the other. There were, the lecturer said, many cases in which great changes of colour were brought about by very slight changes in the physical conditions. Thus a paper saturated with a mixture of the iodides of mercury and copper was a brilliant red when cold, but became dark when slightly warmed and recovered its original colour on cooling. This change was unaccompanied by any known change in the chemical composition. Similarly iodide of mercury changed its colour from bright red to yellow when heated, recovering its original colour on cooling. These changes were, he suggested, due to changes in the bondage by which the constituent colours were connected together.

He thought that changes in the bondage between the atoms of a compound might in many cases be responsible for the emission of light. Moreover,

* See ENGINEERING, March 15, page 287.

ionisation might also arise by the ejection of an electron from the group that helped to bind together the various atoms of a compound. If we considered the arrangement of these bonds, it was evident that the linkage between the atoms might be very similar in different molecules. Here, possibly, was to be found the explanation of a rather puzzling phenomenon in the matter of ionising potentials. The work required to extract an electron from different molecules had been the subject of many careful experiments. The results came out at about the figure that would be expected in the case of hydrogen and helium, yet considering the gases as a whole it was evident that there was a tendency for these ionising potentials to be much the same for all, the average value being somewhere in the neighbourhood of 10 volts. There was thus not much apparent connection between this ionising potential and the chemical properties of a gas, as is clearly shown in Table I.

TABLE I.—*Ionising Potentials for Different Gases.*

Gas.	Hughes.	Franck and Hertz.	Gas.	Hughes.
He	—	20.5	Hg	10.2
Ne	—	16	HCl	9.5
A	—	12	CO	7.2
H_2	10.2	11	CO_2	10.0
O_2	9.2	9	NO	9.3
N_2	7.7	7.5	CH_4	9.5
S	8.3 ?	—	C_2H_2	10.0
Cl_2	8.2	—	C_2H_4	9.9
Br_2	10.0	—	C_2H_2	9.9

It was remarkable that the ionising potential for nitrogen was the lowest of any, with the possible exception of CO. This approximate constancy of the ionising potential might be attributed to mechanical impurities mixed with the gas. For example, if hydrogen were present and if it ionised more easily than other gases, the apparent ionising potential would be that of the hydrogen admixture. It was not easy to see, however, how the figures recorded for carbon monoxide could be accounted for on this line, since the ionising potential of this gas was less than that of either of its constituents and much less than that of hydrogen. Again it was noteworthy that such intensely electro-negative elements as oxygen, sulphur and chlorine had smaller ionising potentials than hydrogen. It would be natural to expect that as electro-negative elements had a strong affinity for negative electricity it should be more difficult to extract an electron from them than from hydrogen. These considerations led the speaker to think that the ionisation of the gases in question was effected by extracting an electron from the bonds connecting the two atoms of the molecule rather than from the atom itself.

It was of interest to note that the linkage between atoms could be altered without detaching an electron. When hydrogen and chlorine combined under the action of light to form HCl the combining gases showed no trace of conductivity. The speaker had tested this with the most delicate apparatus. It was thus evident that to form HCl it was not necessary to pick either the chlorine or the hydrogen molecule to pieces by taking out an electron, and then to put the pieces together again to form the compound, restoring the electrons removed in the process. The two elements combined, in fact, without any detachment of an electron from the positive nuclei.

There was, the speaker continued, a peculiar relation of a general character between the combining weights and the chemical properties of the elements. As he had already pointed out, if we considered the atom as consisting of a positive nucleus surrounded by electrons, the maximum number of electrons in a shell was eight. There were reasons for supposing that the number of electrons in the atom was somewhere about one-half the atomic weight. That was to say, it was equal to the atomic number, which was defined as the position of the element when arranged in the order of its atomic weight. Thus, the atomic number of hydrogen was 1, that of helium 2, of lithium 3, and so on. The ordinary view was, as stated, that the number of electrons in the atom was equal to this atomic number, but the speaker would suggest that it was not strictly correct. According to another way of looking at the matter, the number of electrons present was not quite equal to the atomic number, and this view fitted in much more closely with the actual properties of the elements than did the ordinary view.

The evidence as to the number of electrons in the atom was all derived from a study of the scattering produced by these electrons when exposed to the action of Röntgen rays. These experiments led, as stated, to the conclusion that the number of electrons in the atom was about one-half the atomic weight. This conclusion should not, however, be pressed too far, and the experimental figures might well be subject to a correction of 10 per cent. or 20 per cent., due to the fact that in interpreting the results observed, the help which one electron might give to another, if the wave-length used were too long, had been neglected. It had been assumed that the effects measured were proportional to the number of electrons present, but if the wave-length were long compared with the distance between the electrons the effect would be proportional to the square of the number of these electrons. He did not suggest that the wave-lengths used were as long as that, but there was also no reason to suppose that the wave-length was so short that the results were simply proportional to the number of electrons present. In fact, experiments showed definitely that the energy scattered in the direction of the incident radiation was greater than in the opposite direction, which made it certain that the particles responsible for the scattering were not acting entirely independently, but that interference was taking place.

Hence a certain adjustment in the number of electrons as deduced from experiments on scattering was permissible. The awkwardness of the usual view was well shown by lithium. This element had 3 as its atomic number. On the ordinary view there would thus be three electrons in the outer ring. These electrons were, however, associated with the valency of the atom, which was considered to be equal to the number of these electrons in the outer shell. Lithium was, however, mono-valent and ought, therefore, to have one and not three free electrons. Similarly, carbon had the atomic number 6 and should, on the view criticised, have accordingly six free electrons. All the evidence we had indicated, however, that the carbon atom was tetrahedral with one electron at each corner, or four free electrons in all. In both cases, taking the electrons as equal to the atomic number gave two electrons too many in the outer shell, and this rule held throughout.

The view he proposed to substitute for that hitherto in vogue was connected with a very conspicuous property of the atomic weights, which was indicated in the annexed table :—

Element.	Remainder.	Element.	Remainder.	Element.	Remainder.	Element.	Remainder.
H	1	C	0	Na	3	S	0
He	0	N	2	Mg	0	Cl	3
Li	3	O	0	Al	3	K	3
Be	1	F	3	S	0	A	0
B	3	Ne	0	P	3	Ca	0

This comprised a list of all the elements up to calcium, and the figures given showed the remainder left after dividing the atomic weight by four. With but two exceptions, Be and N, this remainder was either zero or three. If no law were involved the residue was equally likely to be 0, 1, 2, or 3.

He thought that the explanation of this striking peculiarity was bound up with the constitution of the central nucleus of the atom. This nucleus was considered to be made up of an aggregation of unit-charges of positive electricity, each equal to the hydrogen nucleus. If we took this view, something was required to drag the components of the nucleus together. If the positive charges repelled each other to the bitter end, such a nucleus could not exist, and he had accordingly suggested that the law of force was such that at sufficiently small distances the repulsion changed to an attraction. He thought a study of this positive nucleus would repay attention. For the present he would only point out that a certain constitution of these nuclei would involve the property that the number of electrons was two less than the atomic number and would thus fit in with the chemical valency. He could, however, give no reason why the nucleus should have the peculiar structure he was about to describe.

He would suppose that the atoms comprised in their nuclei elements like the nucleus of helium, which contained four units of positive electricity. Embedded in this nucleus he would assume that there were two electrons. As another constituent element of atomic nuclei he would suppose another group of four unit charges, but the charges in this case were units of negative electricity. Now from the table* given in Lecture II., four electrons could not be held together in stable equilibrium by two units of positive electricity. There must be three or four such units. He assumed that the nucleus of all the stable elements was built up of elements like the helium nucleus, together with other tetrahedral elements in which the positive charges at the corners were replaced by negative charges, these being held in position by a sufficient number of positive charges, viz., either three or four.

With this constitution possible atomic weights would be $4p +$ the positive charges in the negative units. All chemical elements would thus have atomic weights represented by $4p + 0$; $4p + 3$; or $4p + 4$; so that dividing the atomic weight by four would leave either zero or three as the remainder. This result was in accord with the table given above and the valency also came out correctly. Thus lithium, with an atomic weight of 7 would have at its centre one helium nucleus giving four positive charges and two electrons embedded therein, and one "inverse" nucleus with four negative charges and three positive charges. One additional electron would thus be required to render the atom neutral, and this would lie in the outer ring, giving a mono-valent atom. Similarly, carbon might be conceived as having its centre built up of two helium units, together with one of the inverse negative units. The two helium units would imply the existence in the centre of the atom of eight positive charges and four negative ones. The one negative unit would bring with it to the centre four negative charges and four positive ones. The atomic weight being equal to the number of positive charges would then be 12. The total number of negative charges bound up at the centre would be eight, leaving four for the outer shell, and the atom built up in this way would be tetravalent.

Atoms constituted on these lines would contain two electrons less than their atomic numbers, and their valency would be in accord with experience.

THE INSTITUTION OF NAVAL ARCHITECTS.

The fifty-ninth session of the Institution of Naval Architects opened last Wednesday in the Hall of the Royal Society of Arts, London, when the President, The Earl of Durham occupied the Chair.

REPORT OF THE COUNCIL.

The Secretary (Mr. R. W. Dana) read the annual report of Council, from which we make the following extracts :—

"The continuance of the war has necessarily restricted the work of the Institution, most of whose members are engaged on duties connected with the prosecution of the war and the extension of the nation's shipbuilding resources. The generous recognition this year of the public services of shipbuilders and marine engineers engaged on war work is a testimony to the value of these services, and the Council desire to offer their congratulations to all those members of the Institution who have been thus honoured.

"The membership of the Institution has been maintained, as shown in the table given below, the losses due to death and resignation having been counterbalanced by the election of new members. The total number of candidates of all classes elected in 1917 was 136 (including 42 transfers from one class to another). In addition 160 members have qualified for election as members at this meeting. [Reference was made to the death of distinguished members.]

"Since the last Annual General Meeting the Government scheme for increasing and controlling the output of merchant shipbuilding has been reorganised. The Shipbuilding Advisory Committee (acting under the Shipping Controller), referred to in the last Annual Report, has been dissolved and a "Shipbuilding Council" has been formed under the Chairmanship of the Admiralty Controller. Eighteen members of the Institution

* ENGINEERING, March 1, page 235.

have been appointed by the Government to serve on this body.

"A Committee which was formed by the Council of the Institution under the chairmanship of Mr. S. W. Barnaby to report upon the effects of mine and torpedo explosions on the structure of merchant ships made certain recommendations to the Council which were adopted and submitted to the Admiralty, the Board of Trade, and the Shipping Controller, with a view to directing attention to the better protection of existing and future merchant ships against underwater attack. A copy of this report is appended [see pages 312 and 313 of this issue] and the Council are pleased to state that most of their recommendations were embodied in the Board of Trade Regulations published last June for the guidance of shipowners and masters of vessels. The Council takes this opportunity of expressing their thanks both to the Admiralty and to the Board of Trade for the permission given to make use of data upon which the recommendations of the Council were based.

"As the result of a joint conference of representatives of institutions connected with marine engineering, convened last August at the instance of the Council of the Institution, the British Marine Engineering Design and Construction Committee has been formed, under the chairmanship of Mr. A. E. Seaton, and is at present engaged in collating the various rules relating to marine engines and boilers, with a view to simplifying procedure and ensuring uniformity of practice.

"The question of forming a Joint Council representing the various engineering institutions and societies, to which allusion was made in the last presidential address, has been carefully considered by the Council. Owing to the continuance of the war, it has been thought desirable to postpone this question for the present, but attention may be called to a conference which was held last October under the chairmanship of the President of the Institution of Civil Engineers, at which the subject of the general education and training of engineers was considered. As the outcome of the above conference, the formation of a permanent Joint Committee, representative of various societies and institutions, is under consideration, and this may be regarded as a step in the directions contemplated by the Council of the Institution of Naval Architects.

"Owing to the temporary absence abroad on Government business of the Treasurer the Council have elected Sir Thomas Bell as deputy treasurer during Sir Charles Ellis's absence."

The Gold Medal and Premium.

The annual gold medal of the Institution for the past year has been awarded to Professor G. W. Hovgaard, of the Massachusetts Technical Institute, Boston, U.S.A., for his paper on "The Buoyancy and Stability of Submarines," and the premium to Mr. J. J. King-Salter, R.C.N.C., of H.M. Dockyard, Sydney, for his paper on "The Influence of Running Balance of Propellers on the Vibration of Ships." The Martell Scholarship (1917) has been awarded to Mr. H. C. Carey, H.M. Dockyard, Chatham; and the Earl of Durham's prize to Mr. H. D. Leggett, H.M. Dockyard, Portsmouth.

Members of Council.

The report of the scrutineers, which was read, showed that the following had been elected members of council: Messrs. W. J. Berry, C.B.; John Gravell; James Hamilton; Sir George B. Hunter, K.B.E., D.Sc.; Messrs. Summers Hunter, C.B.E.; A. W. Johns, R.C.N.C.; W. J. Luke, C.B.E.; Sir Herbert B. Rowell, K.B.E.; and Mr. Harold Yarrow. The following were elected associate members of council: Professor W. E. Dalby, M.A., B.Sc., F.R.S.; the Right Hon. Lord Inverclyde, Commander R.N.V.R.; and Mr. Alex. Richardson.

Presidential Address.

The Right Hon. the Earl of Durham, K.G., G.C.V.O., P.C., then delivered the presidential address. He did not propose, he said, to make much reference to the past, but one much respected presence was missing from the annual gathering. The death of Lord Brassey had removed from the list of members one whose friendship, long service and love for the Institution would be treasured and remembered by all those who knew him. The Institution had, on innumerable occasions, had cause to appreciate his wise counsels, genial hospitality, and never-failing readiness to promote its interests.

He would not expatiate upon the names and services of those members of the Institution whom His Majesty had honoured, but he would regard it as an omission if he did not refer to those proofs of good war service on the part of the Institution. That, however, represented only part of the good work done by members of the Institution. As appeared in the report, 18 members were serving on the Shipping Council under the Admiralty Controller. Furthermore, a very strong committee under the chairmanship of Mr. Barnaby, had submitted a report to the Government which was very favourably received by them, and, he was glad to say, the Government had circulated and adopted most of the recommendations. He would like the Government to go further, and not merely suggest that precautions should be taken against mine and torpedo explosions, but issue stringent orders that those precautions must be enforced. Perhaps, in discussing Sir George Carter's paper, Mr. Barnaby would make some further reference to that. It was most important to avoid loss of life or ships by any positive negligence. The mercantile marine were so gallant and recklessly brave as to run some unnecessary risks, and it was all important that useless risks and waste should be eliminated.

As to the present grave national difficulties, his Lordship wished to commit none but himself, but he could not disguise his opinion that the present disquieting and unsatisfactory situation with regard to the shipbuilding crisis was attributable, in a considerable degree, to the paralysing influence which seemed inseparable from the Government control of national institutions. That the Government must control the operations of war was an indisputable truism; but that they should personally manage all the productions whereby war was successfully carried on was a totally different proposition. It was true that the Government employed experts, and others, and it was true that the Institution had 18 members serving under the Admiralty Controller; but they did not control the Controller. During the last few weeks there had been agitations, accusations and recriminations about the low output of ships. He did not think he should misinterpret the views of some of his friends in the North, if he said that they attributed much of the trouble and delay, not to disputes between employers and workmen or unwillingness and lack of patriotism on the part of the workmen, but to inexpert interference and the hustling methods of Government officials. There were various definitions of the word "hustle," one being "to jostle," to use a racing analogy. If a horse or his jockey jostled another horse or jockey, the horse or jockey so acting would be disqualified. His advice to the Government in regard to the great national industries was, "do not jostle." There had been a regrettable diminution in the output of ships, but he believed that there would be a great increase in the near future. When that occurred credit would be claimed for it by the Government and the newspapers—or the newspapers and the Government. The preparations which shipbuilders had made, their quiet spade work, and the facilities which they had created, would be the real determining causes of the future increased output. Freed from the vexatious interference of men who did not know the business half so well as the producers, he was confident that the patriotism of masters and men would overcome the difficulties. If, however, a business so vitally important continued to be mismanaged by incompetent nominees of the Government there would be no real improvement. We must have ships, shipbuilding yards, managers and workmen, but there was no earthly reason why they must be managed by Government officials. There was an obsession, almost a mania, on the part of the Government to interfere with all public and private affairs, by appointing overseers, scrutineers, advisers and controllers, and the waste of time and money by the multiplication of these bureaucracies was positively colossal. He hoped that the Government would begin by reforming their own departments, and protection and assistance would be given; but they must leave industrial establishments to run their businesses without Government interference. If there must be control, let it be by shipbuilders, who were best able to devise means of speeding up the work they had spent their lives in controlling.

The question of standard ships, on which Sir George Carter was to read a paper, had been much discussed. In justice to the Government he should point out that he understood they decided to build these ships as an emergency war measure, to meet the necessity of building ships of a certain quality and design as speedily as possible. The idea of standardisation was, of course, not new to naval architects, and he understood that ships which might be called "standard" had from time to time been built in private yards by individual firms. He believed that the infamous submarine warfare accounted for a measure which would not in ordinary circumstances have any body of weight behind it. But after all the mercantile marine in this country had by its own enterprise built up a shipping business, and not only were the shipowners to be credited with this, but there must also be remembered the readiness of naval architects to design and shipbuilders to construct ships which met the changeful needs and the varying requirements of the shipbuilding industry. In his lordship's opinion it would be a fatal mistake to deprive naval architects of the full exercise of their inventive genius, and to limit their work to certain specified standard designs. It would be difficult for the Institution to promote the progress of the science of the naval architect if no freedom were to be given to individual effort in the way of design. He was fortified in that view by the paper to be read by Mr. Abell on the "Problems of the Future in the Design and Construction of Merchant Ships." Mr. Abell would demonstrate that there was no finality in standardisation. It would be well if the Government would recognise that fact, and allow shipyards to produce ships which they were capable of turning out rapidly.

There was one other matter, sometimes ignored, when the low output of ships was discussed, and that was that the ravages of the war had caused an immense amount of repair work to be imposed on all the shipbuilding yards. In many cases the repairs were urgent, and took priority of all other work. He was not trying to invent excuses for the low output of shipbuilding; all deplored it, and all should be most anxious to increase that output, and he was sure that no naval architect had any desire to thwart or hamper the Government; all would do what they could to help. But the country did expect that the Government would prove that they were handling this most vital question wisely and properly. Shipowners, shipbuilders and employees, on their side, must realise that the country looked to them for the utmost output that they could give—that no exertion must be lacking on their part. It was unthinkable that any petty jealousies or labour disputes should imperil the welfare of the fighting forces or the food supply of the country; or above all the untarnished honour of the Empire in its noble struggle for freedom and peace.

Standard Cargo Ships.

The first paper taken was by Sir George Carter, K.B.E., and dealt with "Standard Cargo Ships." We reprint this important communication on page 307.

The discussion was opened by Sir Alan Anderson, Controller of the Navy, who said that although he could not speak as an authority on the technical aspects of the author's paper, he was glad to have the opportunity of saying something on the general subject and on the administrative questions involved. One of the most striking anomalies brought out by our war experiences was that all who had anything to do with Government departments had been brought to think alike on the matter of Government interference in industry. Those of them who, like himself, had been called in to help the authorities, and those who remained outside, were equally convinced that the less of such interference the better, and that the best results were obtained when people acted as their own controllers. On this head he did not think there was any difference of opinion between himself and his auditors. In war, however, the Government had to interfere, and this interference appeared unnecessary to many people, and undoubtedly would have been so in peace time. Government interference being unavoidable there was no doubt a tendency for the amount of it to grow and for the departments concerned to do more than was really needed. This occurred in war, as in peace, and caused much annoyance. With reference to the low output of merchant tonnage the chairman had suggested that the natural corollary was that the Government departments concerned had managed

matters badly. There had been a lot of such criticism, but much of it would have been stillborn had the full facts been known. He was glad to say that it had now been decided to give to the House of Commons that afternoon figures both as to the loss of tonnage and as to the rate of production. This greater publicity would have a useful effect on public opinion, and many of the criticisms that had appeared in different papers would not have been made had these figures been known. For instance, he was advised that taking into account the amount of repair work done and the number of naval vessels constructed, the total tonnage launched from our shipyards in 1917 was an absolute record. In one way this was a very satisfactory state of affairs, but from another point of view it was disquieting, since in spite of this record performance the result was less than required. This meant that something further must be done, so as to better our best, and this was a very big operation, and was closely allied to the introduction of the standard ship. The ordinary methods of placing orders had to be abandoned and all extravagant types of vessel ruled out. Of course, this plan raised criticism, and no doubt certain mistakes were made. In the ordinary conduct of business, however, they would never get anywhere unless they took the risk of making mistakes, and in war where rapid advances had to be made, some errors must be admitted. The standard ship policy had been subjected to two lines of attack. In the first place it was said that the standard ships constituted nothing new. That shipbuilder A had already got a standard ship suited to his yard and that shipbuilder B had also his own standard. All that had been done it was asserted, was to make A build B's ship and *vice versa*. The second criticism was that the standard ships were not standard at all, and, of course, they were not standardised in the way the Ford car was. What Sir George Carter's committee had done was primarily to cut out all extravagances and to get rid of unnecessary features, which would have been maintained had shipbuilders been permitted to work to their individual ideas. He thought a debt of gratitude was due to the committee for their work in developing a simpler type of cargo steamer and removing complications. Had not this action been taken, the authorities, he was confident, would have had to meet much graver criticism than any with which they had yet been confronted. All sorts of anomalies would have arisen if a free field had been left open to the individual ideas of owners and builders, and it would have been impossible to hold the scales fairly between the different people wishing to place orders. The two main points had been brought out by Sir George Carter. The establishment of standards necessarily involved some delay in getting work started, but we should now begin to reap the benefit of last year's preliminary work. Secondly, the introduction of the standard types had, as the author explained, greatly reduced the number of rolled steel sections called for. Speaking generally, he thought that a debt of gratitude was due to Sir George Carter for his work in tidying up the confused condition of affairs in our shipyards, and he hoped that the returns would soon show a great gain in the merchant shipping output.

Sir Eustace d'Eyncourt, who spoke next, said that the Institution owed a debt of gratitude to the author for his paper, which would have been even more interesting than it was had it not been for the restraint imposed by the censor. There was no question but that the first effect of standardising a product was to cause delay. If the Government decided, which God forbid, that all motor-car makers were to turn out the same car, the first effect would be a complete cessation of output, whilst the necessary drawings, gauges and jigs were being prepared. For similar reasons the yards engaged in the production of standard ships had not yet got fully into their stride, and a progressive improvement might be expected henceforth. One argument urged against standardisation was that it militated against the normal steady improvement in design. Once standards were adopted it was no use listening to people advocating small betterments. The main aim of standardisation was to secure speed in production, and work once started must go forward without modification, which would occasion great delays in delivery, even if the product was improved. The Controller was thus necessarily "up against" people who demanded changes that could not be made. The objection that standardisation hindered improvement, moreover, applied less to cargo-boat construction than to most other work. The tramp steamer was already a pretty good product, bringing in its cargo at a fair speed and being economical to work. Where standardisation was adopted improvements must be made not gradually but in big steps, and without checking continuity of construction.

Mr. Sydney Barnaby, speaking as chairman of the Institution's Committee on the effect on ship's structures of mines and torpedoes, expressed his gratification upon the author's remarks on the value of the recommendations they had made. The Institution had felt when the Shipping Controller was first appointed that there must be a great deal of information scattered throughout the country as to the damage done by mines and torpedoes, and that this information should be collected, collated, and put in the hands of the Controller's Committee. A second point which seemed to require investigation was the serious losses of large passenger steamers. These steamers embodied, so the public had been led to believe, the latest and best practice in naval architecture, and it had not been expected that they should go down as they did. The committee had been prepared to find that the effect of the torpedo on merchant ships was so severe that their survival could not reasonably be expected. They expected to find that large areas of the shell plating were disturbed and the riveting started, and that possibly bulkheads were carried away by a sudden enormous inrush of water. Their investigations showed, however, nothing of the kind. Large as the holes were, the ship's structure was quite unaffected at the distance of a few feet and the bulkheads had never given way. It turned out, in short, that the ships were sinking because the "watertight" compartments were not watertight and rapidly filled when the vessel was holed. He was delighted to note Sir George Carter's statement that most of the committee's recommendations had been adopted for the standard ships. One of the weakest points in the ordinary cargo boat was the reserve coal bunker forward of the boiler room. In the case of large passenger vessels the trouble turned out to be that these floating palaces were built to afford the greatest possible degree of comfort. They were accordingly not divided into watertight compartments, but into compartments that could be made watertight were time available and the conditions favourable. The explosion of a torpedo left no time, however, for this operation, and the Institution's Committee had accordingly advised that all these ships should be divided into really watertight compartments before they proceeded to sea by the closing up of all bulkhead doors. They had hoped that the authorities could have gone further than to merely recommend this procedure. This was the more necessary in view of the extraordinary difficulty there was in turning out new ships as fast as they were at present being sunk.

Mr. W. H. Whiting said that whilst in peace time the satisfactory subdivision of ships into watertight compartments was of extreme importance, it had now become a matter of grave urgency in the interests of national safety. Like the previous speakers, he was delighted to hear that most of the recommendations of the Institution's Committee had been adopted. It had been said in some quarters that these recommendations were impracticable, but this criticism was effectually disposed of by the author's statement, that what they had advised was actually being done. Whilst admitting with the author that safety was a question of degree, he would say that this platitude was in some cases being used to discourage improvements. It was not, however, a matter of indifference whether the chance of a ship surviving attack was one in two or one in ten, which represented approximately the relative safety of different boats. Naturally, no ship was unsinkable, but too much weight was attached to objections to subdivision, based on the difficulty of working the ship, and on possible loss of time in handling cargo. He thought Sir George Carter's reference (Appendix I) to the fitting of watertight doors worked from the upper deck a little perturbing, as it contemplated arrangements at variance with the recommendations of the Institution's Committee. Sliding doors could be closed only slowly. They were likely to jam if the bulkhead yielded, or even as experience had shown, if there were a great inrush of water. For equal safety small ships required to be divided into more compartments than larger ones. Ships supposed to have a certain safety against torpedo attack had been lost in greater numbers, and had sunk more rapidly than could have reasonably been expected. The reason was that the "watertight" compartments were not effectively watertight. We now knew the maximum amount of damage a torpedo could do, and with this knowledge it should of course be merely a matter of calculation as to whether the ships should sink or survive. The committee, in their recommendations, were desirous of limiting the loss of existing ships, as well as providing for the case of new vessels. The speaker believed that these recommendations could be applied to existing vessels. Ordinary cargo boats had at least six bulkheads. Of these the two end ones hardly counted, as the compartments they closed were so small. The committee recommended that the remaining four should be made efficient bulkheads, the doors being permanently closed. Of these four bulkheads, the second one forward was even now made watertight in nine ships out of ten, so that it was only necessary to deal with the remaining three. Until the authorities insisted on this, our losses would continue, and it was high time that the policy of merely making recommendations should be departed from. The committee's recommendations could be, and should be, enforced. Grave as was the position as to cargo boats in this matter of watertight doors, that of the passenger vessels was graver still.

Earl Brassey, who spoke next, said that having been out of England until the past few weeks, he was not entirely *au courant* with the present state of the shipping problem. From what he had heard and seen, however, since his return, he felt convinced that the less the interference of departments with the shipyards the better for the industry. He noted that the reports of the various committees on industrial unrest all gave departmental interference as one chief cause of trouble. Some Government control there must be, but the more matters at issue were left to masters and men the more quickly would we get new ships. He had had some personal experience as to the effects of Government control. A company of which he was managing director had supplied the Italian Government with the whole of the lead produced from Italian mines last year. For the first year of working they had had no contract with the Government, but later on he had discussed with a friend the advisability or otherwise of the undertaking being controlled by the Italian Government authorities, as were all other such undertakings in Sardinia. This friend strongly advised against the proposed step, pointing out that wherever this control had been established in Italy, as here, labour disputes arose. Proceeding, Earl Brassey announced that he proposed to continue the issue of the *Naval Annual* after the war, as he believed it was generally admitted to have proved useful.

Mr. J. W. Isherwood said that in his opinion the author had not justified the policy of standardisation adopted, nor could he concede the claim made that good results had been obtained. So far from this being the case the result as indicated by the output of ships for January and February was a most appalling failure. The policy pursued had not led to any reduction in the staffs of our shipyards, and the claim that it had been necessary in order to reduce the number of steel sections required was badly based. The author's contention seemed to be founded on the practice of many years ago, and he did not seem to be familiar with the progress which had been made for several years past in reducing the variety of steel sections demanded. There would have been no difficulty in allotting steel orders without standardisation of steel sections. As matters stood a builder was now kept waiting for sections which the steel maker was willing and

ready to deliver, until a number of time-wasting formalities had been complied with. But of course this was always a concomitant of government control. Had the firms been allowed to build their own familiar standard types friendly emulation would have been established between the yards and we should have had enthusiastic co-operation in place of apathetic resignation. The author had not done justice to the matter of "unsinkable ships." It was incorrect to say that more steel was required per ton of deadweight carried. The disadvantages of the type advanced by the author were either trifling or non-existent. The speaker had published a design for an unsinkable ship which would carry 3.67 tons of deadweight per ton of steel as against 3.4 tons deadweight per ton of steel in the case of the standard "B" boat, which was an easily sinkable type. The cargo handling arrangements were increased, but were not complicated and the cargo could in fact be handled more rapidly and with less difficulty than with the usual type. The extra time required to build ships with additional bulkheads was negligible, as was proved by experience with tankers. The author had made no reference to the question of the saving of life and goods which would have been effected with unsinkable ships. The speaker agreed with one of the author's conclusions, viz., that in post-war work everything will have to yield to cheapness and rapidity of production. Any system of standardisation which stifled competition and rivalry was bound to be a failure. We would have standard types, but they would be the builder's own standards.

Mr. C. W. Littleboy said that he agreed with a good deal that the last speaker had said, but he also disagreed with much. Shipbuilders asked that there should be no more alteration of designs. As to output, he believed details could be simplified and equipment reduced. He thought hinged masts were a mistake. The mast did little to increase visibility, as the smoke was what was first seen.

Mr. T. Graham said he had visited many shipyards and found very various ways of procedure in vogue. The object of standardisation was to conduce to rapid output, and as matters stood, the question was "under-exposed and under-developed." As to Mr. Isherwood's design, he believed that the claim for unsinkability was based on the use of a water-tight deck, and on the adoption of a low permeability factor. Central control of shipbuilding had become indispensable, but standardisation did not involve merely unity of design. A standardisation of processes was even more necessary. We must have standard plants and standard yards. This was the line along which the construction of destroyers had been developed. Destroyers were not stereotyped structures, but the processes by which they were built were standardised.

Mr. Jas. F. Cowan said that a popular weekly had asserted that the standard ship was doomed, but this view was not consistent with fact. He had tabulated proposals for standardisation in May, 1916, and in all but two items, these proposals had been adopted by the Government. The authorities had not acted on his demand that the full control of the question should be given to a small committee of men with sane and clear vision, nor that Departmental regulations and red tape should be avoided. He did not suppose any one was satisfied with the actual results. and he attributed the failure to excessive Government control. In these days of rations, it might be well to go a step further and ration controllers. He feared that the loyal acceptation of the Controller's requirements described in the author's paper was latent rather than active, and that neither master nor men could be fairly described as enthusiastic. Alterations in ships made after the placing of orders caused constant annoyance.

In reply, Sir George Carter said it was interesting to learn that the total tonnage last year was a record, but, nevertheless, all were agreed that the output of merchant shipping was too low. In connection with the remarks of Mr. Barnaby and Mr. Whiting, he might say that practically the whole of the Committee's recommendations had been adopted. An access trunk was provided from the upper deck to the forward end of the shaft tunnel. Admittedly, the North-East Coast builders of tramp steamers were as capable as any, but many of the biggest yards had no experience in this class of work. In arranging for the standard ships, the requisite knowledge was conveyed to these yards, with the result that they were turning out tramp tonnage as fast as all the other yards put together. One Irish firm, unused to this class of work, was now completing the boats in six months from the date of laying the keel, and similar results must be arrived at elsewhere. As for the delays that had occurred, few berths were vacant when the standard designs were got out, and not 65 per cent. of the steel required by shipbuilders was available for months. Hence, whatever the design, whether the North-East Coast type or Isherwood's, the delay would have been the same. The Committee had considered Mr. Isherwood's proposals, and decided not to adopt them. As to Mr. Littlewood's complaint as to alterations being made, the most important of these were due to the decision to build 30 of the ships, so that they might be used as tankers. Not all the 30 were delayed by this decision, since many had not been started.

The author was thanked for his paper.

The second paper on the list was taken at the afternoon meeting, on Wednesday. It was entitled:

THE MOST SUITABLE SIZES AND SPEEDS FOR GENERAL CARGO STEAMERS,

and was read in abstract by its author, Mr. John Anderson. We reproduce it in full on page 323 of our present issue.

The discussion was opened by Professor Welch, who said that all the members would agree that this was an important paper on an important subject. It formed a very useful piece of research; it dealt with the problems involved in a scientific way and pretty fully, and, so far as he could make out, the author's deductions were borne out by actual examples in most cases. There was no doubt that the terminal facilities had a great deal to do with the economic working of ships, and their improvement together with the improvement of the loading facilities on board the ship, would lead to a great advantage being gained. He, the speaker, was not sure that the right order in which to proceed had been made quite clear. We needed the deepening of our trade routes and better terminal facilities, and these should be concurrent. He was not quite clear either as to the intersection of the two lines in the diagram giving the length of the ship. There was the loss due to extra coal per ton displacement, equal to losses in invested capital, due to detention per ton deadweight, and he asked how it came about that when the two losses were equal, it gave the best length of the ship. He thought the sum of the two losses should be the one to determine the length of the ship, when the sum was a minimum. With regard to the symbol E in a circle, he thought the overall efficiency of a ship must be a very complicated one. He thought that it would be better to put ET, to show that it is not the overall efficiency of the ship, but the efficiency regarded in one particular aspect.

Sir John Biles, who followed, said there were two things in research, *i.e.*, the method which he took to be correct, and the other, the data on which conclusions were reached. The present paper was supplementary to one which he, the speaker, had read to the Dominions Royal Commission, dealing with the relation between size of ship and length of voyage in connection with the need for deeper-draught ships. The new point, which the author had developed, was not included; *i.e.*, the author had taken into account the detentions in harbour, and assumed a rate of loading for which he gave data, reaching different conclusions. Professor Biles emphasised the desirability of doing what the paper called attention to, that is to say, giving a very exhaustive consideration to the methods of loading ships to decrease detention in port. Before the author's paper, these points had not been brought out. Whether the conclusions reached by the author might be accepted, was open to question, but Professor Biles did not suggest they were wrong. He called the attention of the members to item 16 of the table, giving the number of days in port, which he regarded as the crux of the problem. The number of days for the largest ship was 13·09, and for the smallest, 2·37; he was not at all sure at having heard of ships as large as 600 ft. long being detained for more than one week. Perhaps they did not handle so much cargo as shown in the table, but they handled a very large amount in the week, and he doubted whether the author's deductions could be extended so far as to reach the conclusion that it took 13 days in port to unload one of the vessels referred to. Professor Biles thought it was desirable to investigate from the shipowners' and shipbuilders' point of view, whether much more rapid loading and unloading methods could not be obtained. He asked whether the author had considered the handling of cargoes other than derrick cargoes, such as grain cargoes, which can be poured into a ship.

Mr. A. T. Wall thought the permanent charges such as brokerage, tonnage dues, depreciation, insurance, &c., could be more or less ignored as not utilising labour and material to any great extent. The chief thing to be considered was the maximum ratio of deadweight carried to expenditure on labour and material; the first cost of building could be taken as a good measure of the expenditure, so that ratio of deadweight carried to first cost became the guiding factor. The derrick capacity shown in the author's paper as full capacity was much above those in existence at the present time. As the terminal facilities were improved, Mr. Wall believed the ships would automatically increase in size, because with increased derrick capacity one could afford to go to greater ship sizes without losing much economy. A deduction which had struck Mr. Wall was the question of the effect of speed on the cargo efficiency. Referring to the author's diagram, in which cargo efficiency was expressed on a speed base, if taken on a long voyage of 8,000 knots, the best speed of the ship was 9·5 knots; if the speed were increased to 11·5 knots, one only got from 90 to 95 per cent. of cargo efficiency, and if increased to 14 knots this efficiency became 75 to 80 per cent.

Sir William Smith, dealing with the author's E in a circle, found that it was rather a definition of the advantages of trading on one route, than the efficiency of a particular ship. He suggested that Mr. Anderson, as time went on, should check his formulæ and if necessary write another paper at a later date embodying the results of his revised investigations. He also hoped that the author would turn over in his mind what had been said about the meaning of efficiency.

Mr. Findlay thought that many factors had to be taken into consideration before the dimensions of a proposed new vessel could be satisfactorily determined. The author dealt impartially with the advantages and disadvantages of the large steamers generally, but he (the speaker) did not think the balance was held quite evenly. He found that the author's Table I contained a large amount of valuable information, but it dealt only with vessels of 11 knots speed; he asked whether Mr. Anderson could not give corresponding particulars calculated for the various ships at the speeds of 8, 9·5, 12·5 and 14 knots.

Mr. C. I. Davidson said that in many cases the appliances on board had very little to do with the time the vessel was in port. He mentioned a case in which a ship discharged 3,000 tons, the whole of the cargo, in one day; the next voyage the same cargo took three weeks to discharge, so that the formula dealing with the time basis had to be received with great caution. The author, he found, somewhat handicapped the long vessel by the adoption of the formula for breadth, and suggested a variation. The author drove his short and long vessels of the same beam at varying speeds. Obviously we would not drive vessels 14 and 8 knots with quite the same beam. It seemed to him, the speaker, that the percentage of erections on the vessel were the same in all cases; the amount of the erections on a vessel was a recognised method of strengthening the longer ship.

Mr. Robb asked the author to amplify his statement to the effect that the ultimate object was that the vessels should transport the maximum amount of cargo in relation to their initial cost

and at the cheapest freight rate. Had the maximum amount of cargo in relation to initial cost any bearing on the subject? It seemed to him reasonable to point out that we were not working upon freight rate as a measure of the earning capacity of a ship. Freight rate was a measure of the work done in transporting the cargo. He was aware that the difference between the results obtained by measuring the facility of the ship in the author's method, and measuring them in a freight rate basis was probably very small. He asked the author whether he had any idea of the effect of varying the proportions of the different charges on the ship.

Mr. Jackson presumed, from the information given, that Mr. Anderson had worked on the data obtained from ships for a definite route and designed not necessarily for a special cargo but for conditions which were pretty well known. If that were not so, there were one or two cases not raised in the paper, which needed consideration, among other questions that of tramp steamers, built, say, for carrying coal to the River Plate, mixed cargo to the States, returning thence with cotton or grain. One could, for example, better depend on getting a cargo with a 4,000-ton deadweight ship on a charter at these places than if the ship were longer. There was justification for the smaller type of ship.

In the course of a brief reply to the discussion Mr. Anderson agreed that it would be desirable to add something to his definition of efficiency. He added that his notes were a development of Sir John Biles' paper of 1900, and Sir John had not covered certain factors in connection with the cost of handling cargo. In regard to speed he had figured on that of 9·5 knots as being the most economical for the general trader. He quite saw that a vessel designed for particularly heavy weather would perhaps benefit by a greater speed than he had suggested. With reference to the criticisms it would be noticed that Mr. Davidson's suggestion made a change in the arrangements which he, the author, had been working on, and some correction would have to be made for that. He agreed that the freight rate in normal times would be a limiting factor, but in the present instance he had considered the needs of the nation as well as the actual freight rate. He thought, considering the effect of variations in insurance and other costs, and that if the figures were less than he had stated there would be a slight increase in the length of the ship. It had been found that a vessel of between 360 and 400 ft. was the most suitable for the general cargo tramp.

On the motion of the President a hearty vote of thanks was accorded to the author.

(To be continued.)

PLANING MACHINES OF CONCRETE.—We read in *The Iron Age*, New York, that two gigantic metal planing machines, the principal parts of which will be of monolithic reinforced concrete construction, this including the beds, housing of plattens, with cast-iron for bearing surfaces, are being built by the Amalgamated Machinery Corporation, Chicago. The work of the machines is the planing of beds for long gun-boring machines. The concrete beds of the planes are 184 ft. in length; the plattens are 90 ft. long and 13 in. thick. The width between housings is 72 in., and the cross-rail, which is stationary and faced with cast-iron, is 4 ft. square. They will plane 36 in. down to 20 in.

INDUSTRIAL RECONSTRUCTION COUNCIL.—The propaganda work on behalf of self-government for industry which the Industrial Reconstruction Council is specially formed to undertake, is developing at a rapid rate. Following on the success of the inaugural meeting at the Guildhall, a national campaign has been planned, and meetings are arranged under the Lord Provost of Edinburgh, and the Lord Mayors of Manchester, Birmingham, Sheffield, Norwich and Nottingham. In Manchester, Mr. G. H. Roberts, the Minister of Labour, and Sir William M'Cormick, chairman of the Industrial and Scientific Research Department, will be the leading speakers. In Edinburgh and Birmingham, Dr. Addison will again speak under the auspices of the council. Sir Charles Allom and Mr. Wilfrid Hill, a member of the Whitley Committee, have recently been added to the executive. The council's explanatory pamphlet on "Trade Parliaments," which is the fullest explanation yet published of the Whitley Report, has, we understand, run into the third edition, and the demand is still greater than the supply. Negotiations are now proceeding for the establishment of local branches of the council in all the leading industrial centres, and those who are interested in this important work and are prepared to assist, will be welcomed by the committee. The address of the secretary is 8, Bouverie-street, E.C. 4.

INDUSTRIAL NOTES.

THE first "Whitley Report" on the relations between employers and employed dealt with the industries in which there already exist representative organisations on both sides. A second report has been prepared dealing with industries in which the degree of organisation is either not so great, or nil. This report is now issued by Dr. Addison, Minister of Reconstruction, who, in a prefatory note, states that its recommendations are being reviewed by his Ministry and the Ministry of Labour in the light of the practical experience gained in establishing Joint Industrial Councils, and that a statement will shortly be issued detailing any modifications which may be considered expedient from the administrative point of view.

The Committee on Relations between Employers and Employed (the Whitley Committee) of the Ministry of Reconstruction have presented a supplementary report on "Works Committees," *i.e.*, joint committees of employers and employed in each factory, workshop or coal pit, the formation of which was advocated in the first Whitley Report. This supplementary report is issued to the public by Dr. Addison, Minister of Reconstruction.

It points out that in every industry there are certain questions such as rates of wages and hours of work which should be settled by district or national agreement. With any matter so settled no Works Committee should interfere. But there are also many questions affecting daily life and comfort, the success of the business, and the efficiency of working which are peculiar to each individual workshop or factory. The purpose of a Works Committee is to establish and maintain a system of friendly co-operation and discussion between employers and employed on all these matters. There is one danger which the committee think should be specially guarded against: "We think it important to state," they say, "that the success of Works Committees would be very seriously interfered with if the idea existed that they were used or were likely to be used by employers in opposition to trade unionism. It is strongly felt that the setting up of Works Committees without the co-operation of the trade unions and the employers' associations in the trade would stand in the way of the improved industrial relationships which in these reports we are trying to further." As to the method of working the report says: "Works Committees, in our opinion, should have regular meetings at fixed times, as a general rule, not less frequently than once a fortnight. They should always keep in the forefront the idea of constructive co-operation in the improvement of the industry to which they belong. Suggestions of all kinds tending to improvement should be frankly welcomed and freely discussed. Practical proposals should be examined from all points of view. There is an undeveloped asset of constructive ability—valuable alike to the industry and to the State—awaiting the means of realisation. Problems, old and new, will find their solution in a frank partnership of knowledge, experience and goodwill. Works Committees would fail in their main purpose if they existed only to smooth over grievances. We regard the successful development and utilisation of Works Committees in any business on the basis recommended in this report as of equal importance with its commercial and scientific efficiency; and we think that in every case one of the partners or directors, or some other responsible representative of the management, would be well advised to devote a substantial part of his time and thought to the good working and development of such a committee."

The committee urge that both employers and employed, in contemplating the formation of National and District Industrial Councils should go closely into the benefits of Works Committees so far as they have been proved in actual working of committees both before and during the war. They have recommended that the Ministry of Labour should prepare a report of their working. A memorandum on these lines is in course of preparation, and it will shortly be issued by the Ministry of Labour.

The Ministry of Munitions and the Admiralty desire that such Easter or Spring holidays as are customary in the particular districts or establishments should, as far as practicable, be observed by all establishments engaged on munitions work directly or indirectly. If in any establishment or part thereof it is found essential that work should be carried on during the customary holidays, a special request will be made by the Government Supply Department concerned that the whole or part of the holidays may be cancelled. It will then be for the management to settle with the local representatives of the Supply Department to what extent the holidays should be curtailed. Apart from these urgent cases, if in any establishment a question arises as to the limits of duration of the holiday, the firm should communicate in the case of Ministry firms with the appropriate Area Secretary, or, in Scotland, with the Director of Munitions, and in the case of Admiralty firms with the District Director of Shipyard Labour for the area.

The Director of the Department of Labour Statistics deals, in the *Labour Gazette*, with the state of the labour market, and says that in February, employment continued to be very good generally; enlistments accentuated the shortage of men. The regulation of the consumption of raw materials has, however, necessitated some reduction in the working hours in the textile industries.

Trade unions, with a net membership of 1,052,252, excluding those serving with the forces, reported 9,018 (or 0.9 per cent.) of their members as unemployed at the end of February, compared with 1.0 per cent. at the end of January, and 0.3 per cent. at the end of February, 1917. The increase in the percentage as compared with a year ago was almost entirely due to the cotton industry, in which the so-called unemployment is in the nature of organised short time—the operatives affected not being discharged, but merely suspended in rotation for one week out of four or more according to circumstances.

Of the 3,662,673 male and female workpeople insured under the National Insurance Acts, 1911 to 1916, the number unemployed at the end of February was 32,445 (or 0.89 per cent.), compared with 0.88 per cent. in the previous month, and 0.66 per cent. a year ago. For males and females separately the percentages unemployed at the end of February were 0.40 and 2.00.

The average weekly number of vacancies notified to all Employment Exchanges for the four weeks ending February 8, 1918, was 41,417, as compared with 32,799 in the previous five weeks, and with 42,004 in the four weeks ending February 9, 1917. The average weekly number of vacancies filled for the same period was 31,876, 24,282 and 33,856 respectively. The numbers of workpeople remaining on the live registers at February 8, 1918, were 31,202 men, 58,118 women, 8,713 boys, and 8,874 girls, a total of 106,907.

The changes in rates of wages (including war bonuses), reported to the department as taking effect in February, resulted in a net increase of about 90,000*l.* in the weekly wages of 420,000 workpeople. The principal increases were bonuses, granted under arrangements made by the Ministry of Munitions, of 1*s.* or 1*s.* 3*d.* per shift to straight tonnage men employed in steel-melting shops and rolling mills, and of 7½ per cent., or its equivalent, to men on piece rates at blast furnaces; in both cases men on time rates have previously been granted a bonus of 12½ per cent. Workpeople engaged in boot and shoe manufacture throughout the United Kingdom were also granted substantial increases in their war bonuses.

The number of disputes beginning in February was 82, and the total number of workpeople involved in all disputes in progress was 55,822, as compared with, 93,317 in the previous month, and 11,165 in February, 1917. The estimated total aggregate duration of all disputes during the month was 287,500 days, as compared with 533,300 days in January, 1918, and 43,300 days in February, 1917.

CANADA'S COAL PROBLEM.—The Canadian journal, *Power House*, says that Canada at present imports annually from the United States 4,500,000 tons of anthracite, and from 10,000,000 tons to 14,000,000 tons of bituminous coal, the latter largely for power purposes. It is believed that the American anthracite fields will be exhausted in 100 years. The friendliness of the United States towards Canada has recently been emphasised in this very question of coal supply, but circumstances are conceivable in which the United States might feel compelled, in the interests of their own population, to shut off completely the export of anthracite and to barter their bituminous coal output for particularly necessary Canadian products, such as electrical power, to a greater extent than is now done.

MANUFACTURE OF CHEMICALS IN FRANCE.—According to the bulletin of the American Chamber of Commerce in Paris, reported by *The Engineering and Mining Journal*, New York, France is in no way inferior to any other country as a producer of the raw materials required in the manufacture of chemicals. The streams of France, by hydro-electric development, supply a total of 9,000,000 h.p., an ample supply for her factories. By the judicious use of coal, a by-product of 470,000 tons of tar per year is utilised in the manufacture of dyes. France is at least the equal of Germany in the production of sulphuric acid, and prior to the war her output was 905,000 tons, of which 62 per cent. was obtainable from the resources of the country. About 1,000,000 tons of sodium chloride is produced from the salt marshes and mines of France. Phosphates are abundant in French Northern Africa and nickel and chromium in New Caledonia. In France are to be found the most extensive bauxite deposits known. Since the war, France has greatly increased the number of factories engaged in the manufacture of chemicals.

THE MOST SUITABLE SIZES AND SPEEDS FOR GENERAL CARGO STEAMERS.*

By Mr. John Anderson.

From correspondence which recently appeared in a British technical journal on the subject of the best size and speed of general cargo steamers, it appeared to the present writer that there was a desire for some further definition of these qualities, for the different trades upon which vessels are engaged. The conditions induced by the war have made the subject of national importance, as the new merchant fleet which will be brought into being should be such that the best results will be obtained with the minimum expenditure of material, labour, and time. The ultimate object of all interested in shipping is that the vessels engaged shall transport the maximum amount of cargo in relation to their initial cost, and at the cheapest possible freight rate. The maxima and minima of these requirements are not coincident, and it is therefore necessary to compromise between them. The initial cost of construction of vessels has varied greatly during different periods of the past, and this has made it difficult for owners having different sizes of ships built at different periods to estimate their relative efficiencies on a common basis, *i.e.*, an unsuitable ship built in, say, 1908 might, on account of the very low initial cost, be able successfully to compete against another of better design built in 1913. With the object of combining the interests of the designer, the owner, and the builder, and of eliminating a number of difficult corrections, the writer has endeavoured to formulate a method by which the most economical dimensions can be arrived at, for any length of voyage, condition of loading, or speed.

General.—The efficient part of a vessel's working life is when transporting cargo from one port to another, and the period spent in loading and discharging, although necessary, can only be considered as lost time. The efficiency of a vessel transporting cargo at a minimum speed (which will be defined later) can therefore be expressed at :

$$\textcircled{E} = \frac{T - t}{T}$$

where T is a convenient total period of time, and t is the proportion of T which is required for loading, discharging, docking, &c.

Size of Vessel.—There are many inducements towards building large vessels, the most important of which are :—(1) Reduced initial cost in relation to the deadweight ; (2) Reduced horse-power, crew, and amount of coal required in relation to the deadweight ; (3) Greater seaworthiness. The problem cannot be considered sectionally, however, and an owner is sometimes prevented from utilizing these advantages fully on account of—(4) The length of voyage ; (5) The increased length of time required to load and discharge a large ship (which time might for convenience be termed "Detention") (6) The unsuitability of certain harbours, loading berths, and dry docks ; (7) Greater loss in case of mishap or disaster. The lost time suggested under item 5 is of considerable magnitude, as the number of hatches or derrick systems which can be arranged in vessels of equal proportions will vary as $\sqrt[3]{\text{deadweight}}$, or, with holds of equal length, the work to be done at each hatch will vary as B, D, H, where B and D are the breadth and depth respectively. H (see Fig. 6 overleaf) is the average distance through which the cargo has to be transported.

It will be seen from this and the figures given in Table I that the average work to be done at each hatch in a 250-ft. vessel is about 16,000 ft.-tons as compared with 250,000 ft.-tons in a 570-ft. ship.

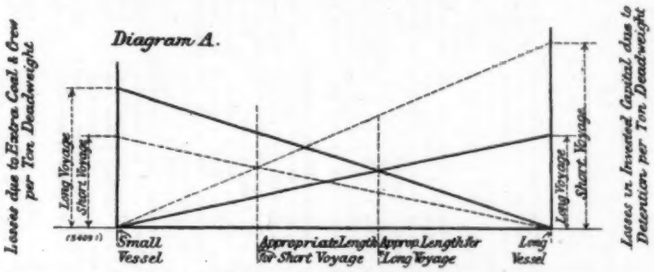


Diagram A.
Losses due to Extra Coal & Crew per Ton Deadweight
Long Voyage
Short Voyage
Small Vessel
Appropriate Length for Short Voyage
Appropriate Length for Long Voyage
Long Vessel
Losses in Invested Capital due to Detention per Ton Deadweight

TABLE I.—Estimated Qualities for a Voyage of 4,000 Nautical Miles and Maximum Derrick Capacity.

Item No.	Particulars.	Speed of Vessels, 11 knots.				
1	Dimensions	250 ft. × 37 ft. × 18 ft. 6 in.	330 ft. × 45 ft. × 24 ft. 6 in.	410 ft. × 53 ft. × 30 ft. 5 in.	490 ft. × 61 ft. × 36 ft. 4 in.	570 ft. × 69 ft. × 42 ft. 3 in.
2	Displacement .. tons	3,031	6,525	11,520	18,360	27,330
3	Draught	16 ft. 7½ ins.	20 ft. 9½ in.	24 ft. 4½ in.	27 ft. 11 in.	31 ft. 7 in.
4	Block coefficient	0.69	0.74	0.76	0.77	0.77
5	Service horse-power	1,258	1,935	2,540	3,230	4,080
6	Weight of vessel .. tons	1,152	1,934	3,260	5,234	7,515
7	Initial cost of vessel	26,700*l.*	44,700*l.*	66,800*l.*	104,900*l.*	153,700*l.*
8	Net tonnage .. tons	700	1,600	3,210	5,400	9,780
9	Crew	24	33	46	56	65
10	Number of Derrick systems—					
	Yardarm	1	2	7	11	12
	Swinging	4	6	2	—	—
11	Gross deadweight .. tons	1,879	4,591	8,260	13,126	19,815
12	Coal consumed per voyage .. tons	389	566	754	978	1,257
13	Stores, fresh water, and feed water .. tons	61	90	121	161	196
14	Net cargo deadweight	1,388	3,885	7,356	11,987	18,362
15	Days on run	15.15	15.15	15.15	15.15	15.15
16	Days in port	2.37	4.15	6.75	8.95	13.09
17	Number of runs per annum	20.83	18.92	16.65	15.15	12.91
18	Total cargo per annum .. tons	28,910	73,500	122,500	181,600	237,000
19	Total coal per annum .. tons	8,102	10,710	12,550	14,820	16,228
20	Cargo transported per annum / Initial cost of vessel	1.082	1.643	1.834	1.731	1.542
21	*Cost of operation per annum*—	£	£	£	£	£
22	Brokerage and management, 9*d.* per ton	1,084	2,757	4,594	6,810	8,888
23	Loading and discharging, 1*s.* 6*d.* per ton	2,168	5,514	9,188	13,620	17,776
24	Coal, oil, &c., at 12*s.* per ton	4,861	6,426	7,530	8,892	9,737
25	Tonnage dues at 1*s.* 3*d.* per ton	913	1,965	3,345	5,120	7,904
26	Wages and provisions	2,017	2,772	3,865	4,705	5,460
27	Depreciation, insurance, repairs (4 initial cost)	3,819	6,393	9,543	14,986	21,964
28	Total outlay	14,862*l.*	25,827*l.*	38,065*l.*	54,133*l.*	71,729*l.*
29	Profit to give 20 per cent. on the initial cost	5,346*l.*	8,950*l.*	13,360*l.*	20,980*l.*	30,730*l.*
30	Rate per ton to give 20 per cent. gross profit	14*s.*	9*s.* 5½*d.*	8*s.* 4½*d.*	8*s.* 5½*d.*	8*s.* 7½*d.*
31	Efficiency $\frac{T-t}{T} = \textcircled{E}$	0.865	0.785	0.692	0.629	0.536

TABLE II.—*To show the Effect of Altered Derrick Speed on Freight Rate and Tons carried at the Appropriate Lengths.*

Condition.	Speed of Vessel.	Derrick Speed.	Freight Rate.	Tons Carried.
	knots.		*s. d.*	
1,000 nautical miles	9½	Max. D.C.	4 9	4.89
	9½	45 p.c. ,,	5 8	3.19
1,000 ,, ,,	14	Max. ,,	5 9	3.49
	14	45 p.c. ,,	7 3½	2.18
4,000 nautical miles	9½	Max. D.C.	7 11½	1.91
	9½	45 p.c. ,,	9 2	1.50
4,000 ,, ,,	14	Max. ,,	10 2	1.47
	14	45 p.c. ,,	12 7½	1.10
8,000 nautical miles	9½	Max. D.C.	11 2	1.075
	9½	45 p.c. ,,	12 6	0.916
8,000 ,, ,,	14	Max. ,,	13 9	0.82
	14	45 p.c. ,,	16 8	0.687

Items 1 and 2 enumerated at the top of this column represent savings in cost of transportation, whereas item 5 represents loss of invested capital; it follows that the most suitable size of vessel is that which gives the best economic adjustment between these opposing factors. (See Diagram A above).

A relatively long voyage or rapid system of loading and discharging will increase the value of (E), while an increase in dimensions or an increase of speed for a fixed length of voyage and fixed derrick speed will reduce it, and from these facts it may be presumed that length (or dimensions) may vary in some proportion to (E).

Method of Calculating Results. — The problem is to find the dimensions which will give the best compromise between items 1 and 2 and item 5, and in order to obtain information covering a wide field, it was decided to calculate the possible working values of 25 vessels, for voyages of 1,000, 4,000 and 8,000 nautical miles, for two speeds of loading and discharging, and for service speeds of 8 knots, 9½ knots, 11 knots, 12½ knots, and 14 knots.

The designs were divided into five groups, each having lengths of 250 ft., 330 ft., 410 ft., 490 ft., and 570 ft., and each group was sub-divided to give the speeds already mentioned.

The arrangement of each size of vessel is shown on Figs. 1 to 5 on the next page ; the length of machinery space is for a speed of 11 knots. In the vessels above this speed it will be increased in length, but it was assumed that this increase would not affect the number of hatches or derrick systems.

Each vessel is of the poop, bridge, and forecastle type, these erections extending over about 50 per cent. of the vessel's length. The ratio of length to depth is 13½ times, this being the maximum which Lloyd's will allow with normal scantlings, and it may also be said that this ratio gives the maximum length for derrick arrangements and minimum draught in relation to the deadweight. The breadth has in each case been made equal to $\frac{\text{length}}{10} + 12$ ft.

The number of winches and derrick systems were arranged to give the maximum number of receiving stations on the quay side, and it was assumed in the calculations that the derricks would be worked on the "yardarm" system if two winches were fitted abreast, and by "swinging" if only single winches were arranged. It has been assumed that the bulkheads are placed so that the work to be done will be equally divided between the winches or derrick systems.

The time required in port was estimated from the derrick capacity, and to obtain a basis for this it was decided to assume that the maximum amount which could be handled per day of 10 hours in the 410 ft. vessels would be 360 tons per "yardarm" system and 276 tons per "swinging" derrick. Proportionate amounts were obtained for the other sizes of vessels by assuming that the time required for hooking and slinging the cargo would be constant, and that the time required for discharging would be proportional to the distance H. On this assumption the following values were obtained :

Length of Vessel.	Working Rate per Day of 10 Hours.	
	Yardarm System.	Swinging System.
ft.	tons.	tons.
250	445	360
330	394	318
410	360	276
490	338	250
570	318	220

The writer is aware that these values are higher than is found in present-day practice, but he purposely kept them high to obtain a wide field and to cover possible future improvements in methods. In order to obtain the lower limit for working rates, alternative calculations were prepared on the assumption that the derricks would be worked at 45 per cent. of the rates given.

It should be pointed out that as these assumptions are made only for the purpose of calculating (E) values in relation to the different lengths of voyage, the quantitative working values are not of importance, and the only object in setting off the relative amounts for each size of ship is to show how the larger vessel may be penalised in discharging speed.

Table I. indicates the method adopted for calculating the working values of the vessels, and the figures shown refer to the 11-knot speed for each size of vessel. The items are generally self-explanatory, but reference may be made to the following :—

(*a*) The draughts are based on present regulations of the Board of Trade, and the block coefficients have been made appropriate to the service speeds. The dictum of the experienced shipowner has been followed with regard to the block coefficient, viz., that it should not exceed .77 whatever the speed may be.

(*b*) The "weight of vessel" used is that of a bare cargo hull to Lloyd's rules, with engines of triple expansion type, these driving twin screws where the service horse-power exceeds 5,200.

(*c*) An addition of 12 per cent. has been made to the calculated time in port, to allow for stoppages during holidays, week-ends, &c., and an allowance has been made for coaling during the 8,000-mile voyage. In addition to these, 14, 18, 22, 26, and 30 days respectively have been allowed for each size of vessel per annum for repairs and other delays, and these have been assessed at their rates per voyage. It has been assumed that coaling will be effected while the cargo is being worked.

(*d*) The coal per voyage has been estimated from a curve, the ordinates of which are 2 lb. per horse-power

* Paper read at the Spring meetings of the Fifty-ninth session of the Institution of Naval Architects, March 20, 1918.

THE MOST SUITABLE SIZES AND SPEEDS FOR GENERAL CARGO STEAMERS.

Fig. 1. DIMENSIONS 250' × 37' × 18' 6"

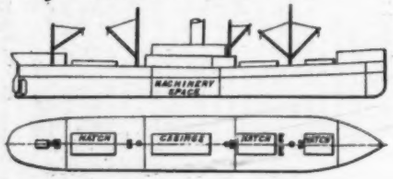


Fig. 2. DIMENSIONS 330' × 45' × 24' 6"

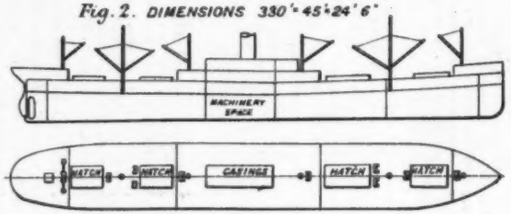


Fig. 3. DIMENSIONS 410' × 59' × 30' 5"

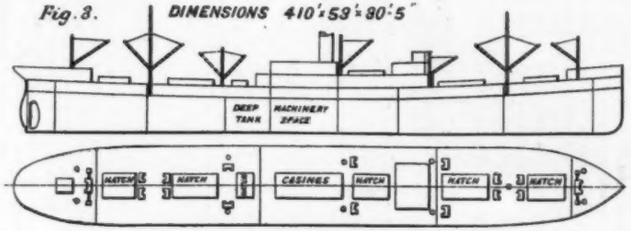
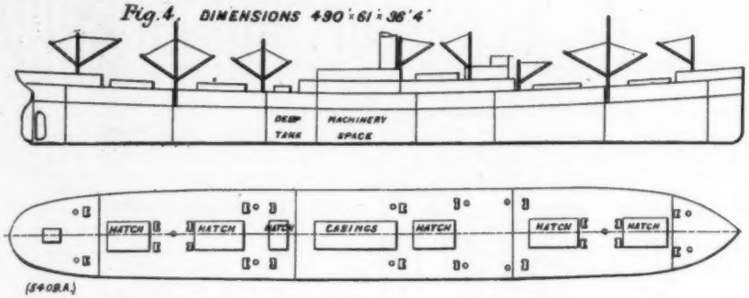
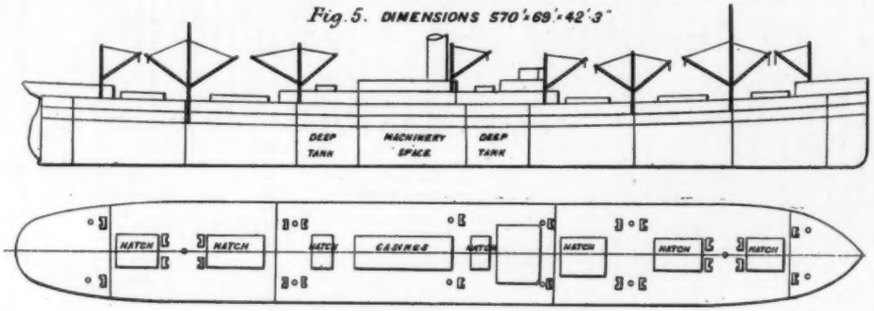


Fig. 4. DIMENSIONS 490' × 61' × 36' 4"



(5408.B.)

Fig. 5. DIMENSIONS 570' × 69' × 42' 3"



per hour at 800 horse-power, 1.7 lbs. at 2,200 horse-power, and 1.6 lbs. where the horse-power is 4,000 or more. The coal for port use has been assumed as proportional to the weight of cargo and the distance H. It was also assumed that vessels making an 8,000-mile voyage would be rebunkered at a port intermediate between the terminal ports.

(*e*) The net tonnage is that obtainable by Board of Trade regulations, and includes the present allowances for propelling space.

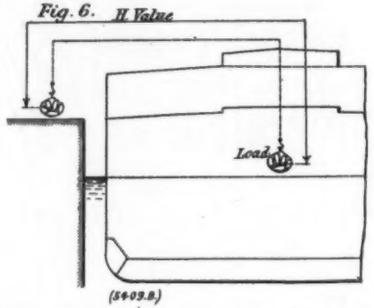
(*f*) The money values are not the present ones, but as they are comparatively correct between each size and speed of ship, and between initial cost of vessel and cost of transportation, they have no influence on the results of the relative efficiencies. Notwithstanding this statement, however, the effect of increased labour and other rates has been investigated, and the results are given later.

(*g*) Line No. 20 in Table I. gives the "tons carried" in relation to the initial cost of vessel, and line 30 gives the estimated freight rates. Cross curves of these have been drawn for each stated condition, and Figs. 7 to 9 illustrate these curves for three of the conditions.

Results.—It will be seen from these curves that the ratio of "tons carried" defines the appropriate length most prominently, but, as cost of coal, labour, &c., must also be considered, it was thought necessary to fix the appropriate length line indicated, by interpolation, between the highest part of the "tons carried" curve and the lowest part of the "freight rate" curve. To complete the main investigation, the appropriate lengths of each condition and distance have been plotted on a base efficiency (E), and these results are indicated on Fig. 10. The spots on this figure for the lengths appropriate to 8,000 miles and 45 per cent. derrick capacity are greater proportionately than those for 4,000 miles and maximum derrick capacity, the explanation of this difference being that the vessels on the longer voyage have intermediate coaling stations. The difference due to this fact does not, however, affect the results to any appreciable extent.

Figs. 7 and 9 represent the extreme limits of efficiency

Fig. 6. H Value



(5409.B.)

for the calculated conditions, their relation being $\frac{8,000}{1,000} \times \frac{1}{0.45} = 17.8$ times the loading speed, or length of voyage, and it is thought that from these and the curves on Fig. 10, lengths appropriate to best results for any known or average length of voyage, condition of loading or speed, can be obtained, for vessels engaged in the carriage of cargo only and having no assistance from the revenue obtained by carriage of passengers.

To illustrate the effect of increased cost of coal, labour, and tonnage dues over the originally calculated amounts, additional lines have been indicated on Fig. 8 to show the effect of increasing the cost of these items by 20 per cent., and it will be seen that although this would tend to increase the appropriate length, such increase would not be of great magnitude. Some calculations have been made to find the effect of vessels making return voyages in ballast trim, and it has been found that if the ballast run is estimated as an extended length of voyage, and not as lost time, in calculating the (E) value, a correct result will be obtained.

Fig. 11 gives the relative "tons carried" and "freight rate" in terms of speed for the appropriate lengths, and these have been plotted as a percentage of the best and lowest results. It will be seen that the most economical speeds are from 9 knots to 9½ knots, but it is understood that higher speeds are necessary when cargoes of a perishable nature are carried.

It has not been found convenient to illustrate the curves for each calculated condition of loading, but Table II. is given to show the effect of altered discharging speed on the "tons carried" and "freight rate."

Other Types and Proportions.—The appropriate lengths shown on Fig. 10 will be applicable to other types of cargo vessels, provided that in comparing the dimensions of one vessel with another the characteristics and proportions are similar.

Stowage Capacity.—Stowage capacity will often influence a designer in arriving at the most suitable size of a vessel, and it is found that the stowage rate per ton of cargo for fixed speed is reduced as length is increased; it may, therefore, in some cases be found profitable to choose a slightly shorter vessel than the curves indicate.

Improved Types of Machinery.—The effect of geared turbine installations with double reduction gears has also been investigated from the particulars given on Fig. 12, and the results are plotted for speeds of 11 knots and 14 knots on Fig. 8. It appears that these improved propulsive elements with reduced coal consumption would not appreciably alter the appropriate length of vessel. They, however, affect the earning power considerably, and on account of the present relatively high initial cost of this type of engine for low powers, geared turbines are evidently unsuitable for speeds of less than about 10½ knots.

Conclusions.—It appears from these investigations and the results of actual ships tabulated hereafter that the most suitable length of a "tramp" trader would be between 380 ft. and 400 ft. with a speed of 9 knots to 9½ knots. The maximum efficiency (E) of the most up-to-date cargo lines does not exceed 0.60, which with a speed of 12½ knots would have a length of about 450 ft. and a corresponding maximum draught of about 28 ft. In view of his maximum draught, it appears to be an open question whether the proposed deepening of trade routes should be considered prior to legislation being completed for improvements in our harbours, such as increased berthing and loading facilities at quays, increased storage capacity, and the removal of many port restrictions which have caused detention to our ships in the past.

The curves of gross deadweight given on Fig. 13 will be found useful for comparing one vessel with another.

The writer desires to thank the directors of Messrs. Scotts' Shipbuilding and Engineering Company, for their permission to publish these results. He also thanks the friends who have advised and assisted him in the development of these notes.

APPENDIX.

To show the possible use of, and the method of applying, the curves on Fig. 10, the following illustrations are given :—

No. 1.—A cargo tramp, 400 ft. in length, and having five hatches, each of which is worked by derricks at one end, has the following characteristics for the period under consideration :—

		Tons.
Load deadweight		8,000
		Days.
Total steaming time		310
Total loading and discharging time ...		255
Total time for coaling, repairs, &c. ...		30
		Knots.
Average service speed		10½
Is this the most economical length ?		
		Days.
The total period T is	=	595
The efficient period T − *t* is ...	=	310
Giving an efficiency of (E) ...	=	0.52

The length corresponding to (E) = 0.52 and a speed of 10½ knots from Fig. 10, page 325, is 370 ft., but this reduced length is accompanied by a reduced deadweight, and, consequently, an increased efficiency. This variation in efficiency suggests that a length of

THE MOST SUITABLE SIZES AND SPEEDS FOR GENERAL CARGO STEAMERS.

Fig. 7. 45 PER CENT. DERRICK CAPACITY. 1000 NAUTICAL MILES

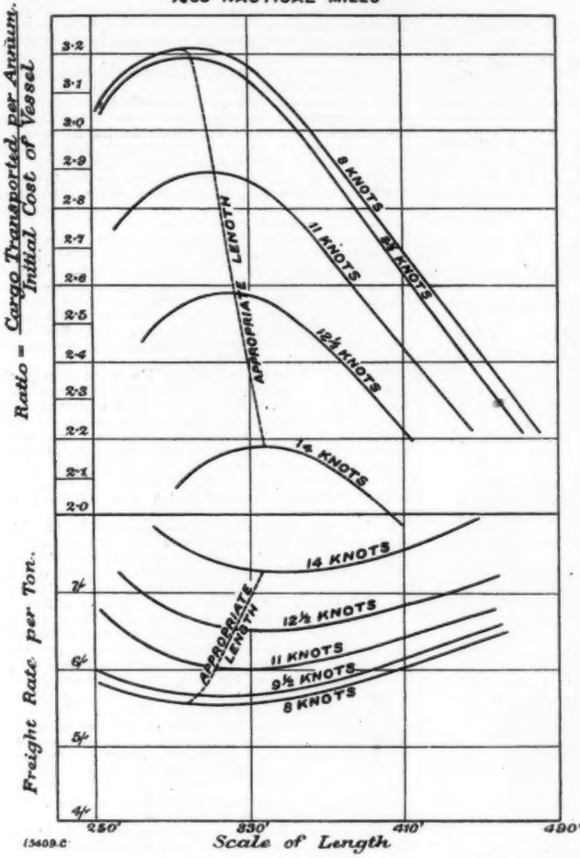


Fig. 8. MAXIMUM DERRICK CAPACITY 4000 NAUTICAL MILES

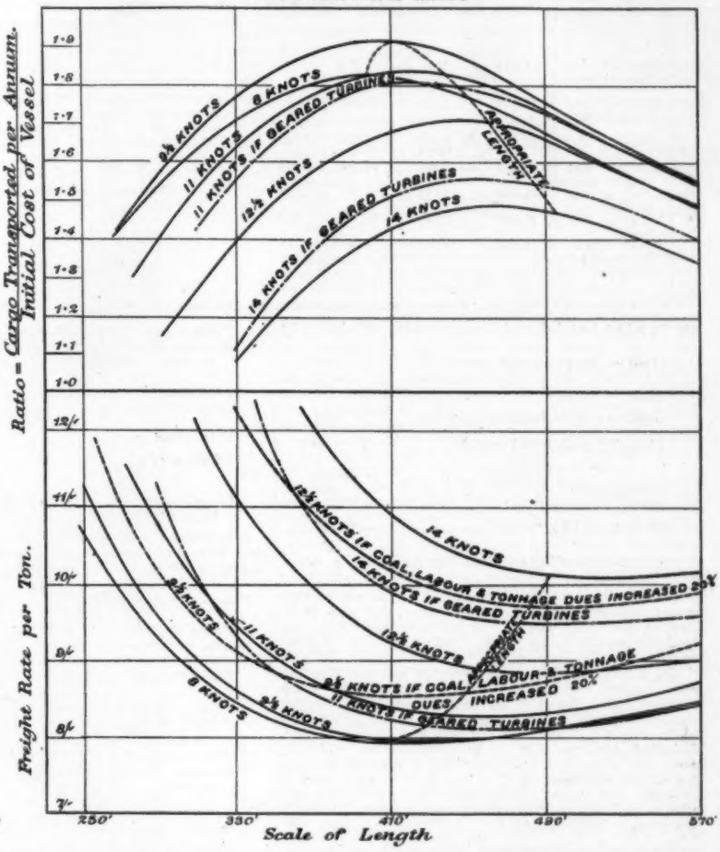


Fig. 9. MAXIMUM DERRICK CAPACITY 8000 NAUTICAL MILES

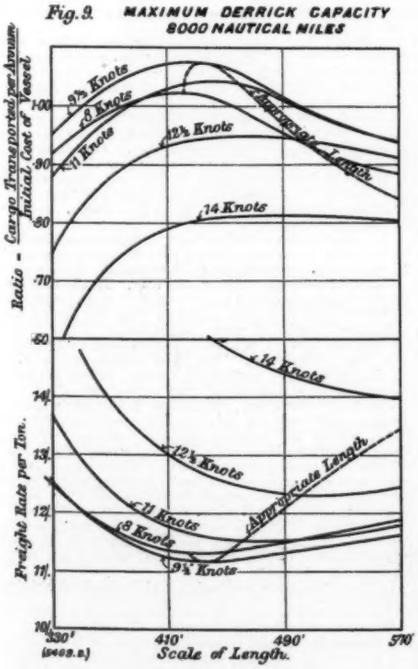


Fig. 10. APPROPRIATE LENGTH IN TERMS OF EFFICIENCY.

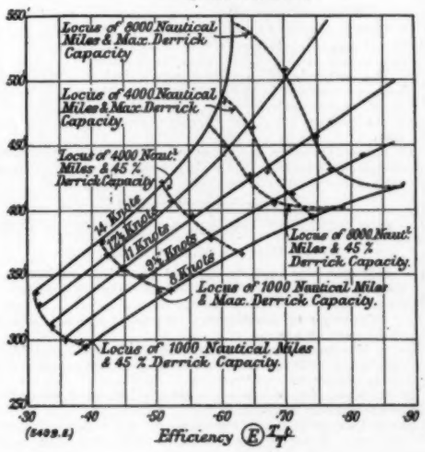


Fig. 11.

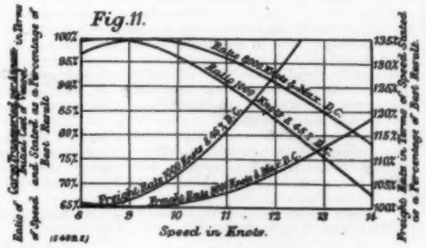


Fig. 12. DIAGRAM SHEWING RELATIVE VALUES FOR TURBINE INSTALLATIONS WITH DOUBLE REDUCTION GEARING IN COMPARISON WITH TRIPLE EXPANSION RECIPROCATING ENGINES OF SIMILAR POWER.

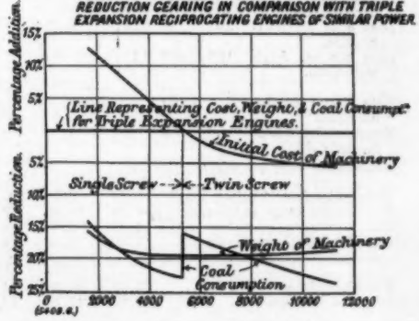


Fig. 13. GROSS DEADWEIGHT.

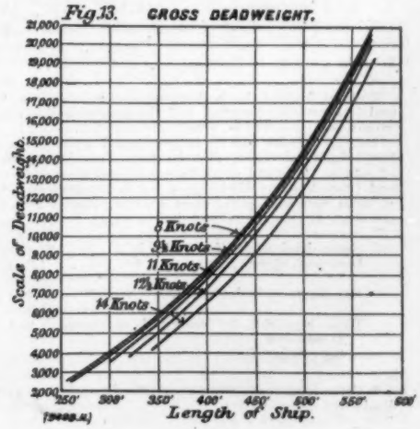


TABLE III.—PARTICULARS OF THE WORKING QUALITIES OF CARGO SHIPS COMPARED WITH THE CALCULATED RESULTS GIVEN BY FIG. 10.

No.	Trade Route.	Approximate Length of Voyage.	Length of Ship.	Service Speed (Knots).	Total Time per Trip (Days).	Steaming Time (Days).	Corresponding (E) Value.	Length from Curves, Fig. 10.*	Remarks.
			ft.		T	$T - t$		ft.	
1	Liverpool and United States	8,500	410	10.25	63	34.7	0.55	390	Round voyage, outward in ballast, average of four voyages.
2	Liverpool and United States	11,000	365	10.60	82	47.0	0.574	382	Round voyage, outward in ballast, average of three voyages.
3	Liverpool and Far East	25,000	390	10.70	149	99.0	0.665	420	Average of four round voyages.
4	Liverpool and Pacific Coast	30,000	503	13.00	161	94.0	0.585	460	Average of four round voyages.
5	Liverpool and Far East	25,000	452	13.80	128	71.0	0.555	445	Result of one round voyage.
6	Leith to Far East	25,000	390	10.30	182	105.0	0.575	388	Result of two round voyages.
7	British and Continental Coasting	1,500	215	8.0	16	7.1	0.445	276	Result of three years' service.

* Corrected for change of efficiency due to change of length and number of derricks in terms of gross deadweight.

380 ft. might be tried, and the particulars would then be

	Tons.
Deadweight (from Fig. 13)	7,050
	Days.
Time on voyage	310
*Loading and discharging time $255 \times \frac{7,050}{8,000}$	225
Time for coaling and repairs	30
	Days.
Total period T ... ... =	565
Efficient period $T' = t$ ... ... =	310
Giving an (E) value of	0.548
	Ft.
The corresponding and final length would then be	377

The detail curves for the condition nearest to this vessel's efficiency show that if the vessel had been 23 ft. shorter the "tons carried" would have been increased by 1 per cent. and the "freight rate" reduced by ¼ per cent.

No. 2.—Proposed vessel for service between Bombay and Glasgow, or neighbouring ports, a distance of 6,500 nautical miles. Speed on service, 11 knots. Full cargoes can be obtained on all voyages, and it can be handled at an average of 150 tons per derrick system per day. Swinging derricks only to be arranged for, and the cargo can be handled over both sides of vessel at Eastern ports, but will be worked to and from a quay wall in Britain. The vessel will bunker before embarking and also at an intermediate port on each voyage. What is the most suitable length?

		Ft.		Ft.		Ft.
Lengths		360		400		440
		Tons.		Tons.		Tons.
Gross deadweight per Fig. 13.		5,750		7,750		9,900
Less coal for half-voyage.	530	630	620	740	710	850
Less stores, fresh water, &c.	100		120		140	
Nett cargo to be handled.		5,120		7,010		9,050
Number of derricks on each side.		8		9		10

Estimated time per trip :—

	Days.	Days.	Days.
Time to load at Bombay ...	4.27	5.20	6.03
Time to discharge at Glasgow	8.54	10.40	12.06
Time to coal on route? ...	2.00	2.00	2.00
Time for shifts in harbour, &c., and all other delays.	3.00	3.00	4.00
Total lost time	17.81	20.60	24.09
Total time at sea	24.60	24.60	24.60
Total time per trip ...	42.41	45.20	48.69
Efficiency (E)	.058	0.545	0.50
	Ft.	Ft.	Ft.
Lengths per Fig. 10 for these efficiencies.	402	389	376

Column 2 gives the best agreement between the trial and the resulting lengths, and the most suitable length would be about 395 ft. long.

No. 3.—Vessel 600 ft. long engaged on a voyage of 5,000 nautical miles, and having a service speed of 12 knots. Thirteen derricks are arranged on each side, and these load or discharge from lighters on each side at each terminal port, each at the rate of 200 tons per day. Is this the most suitable length?

	Tons.
Gross deadweight (from Fig. 13) ...	23,500
Less coal, stores, fresh water, &c. ...	1,900
Net cargo to be handled	21,600
	Days.
Time required to load and discharge $\frac{21,600 \times 2}{26 \times 200}$	8.3
Time required for coaling and shifting...	3.0
Average time lost for repairs, &c., per voyage	2.7
Total lost time per voyage	14.0
Total time sailing	17.4
Total time per trip	31.4
Efficiency (E) $\frac{17.4}{31.4}$ ... ... =	0.555
	Ft.
Length corresponding to this efficiency from Fig. 10 ... ... =	412

It is evident that the efficiency will improve considerably with this reduced length, and on this account a length of 460 ft. having 10 winches each side might be tried.

The particulars would then be—

	Tons.
Gross deadweight (Fig. 13) ...	10,700
Less coal, stores, fresh water, &c. ...	1,200
Nett cargo to be handled	9,500
	Days.
Time required to load and discharge $\frac{9,500 \times 2}{20 \times 200}$	4.75
Time required for coaling and shifting...	2.45
Average time lost for repairs, &c., per voyage.	2.0
Total lost time per voyage	9.20
Total time sailing	17.4
Total time per trip	26.6
(E) value	0.654
	Ft.
Corresponding length	460

This smaller vessel would transport 15 per cent. additional cargo in relation to the initial cost, and the freight rate would be reduced by about 4 per cent.

The writer is not aware of any existing vessel of the basis particulars in this latter case, but such a length, speed, and length of voyage has been suggested by Sir John Biles in his paper to the Institution in the year 1900.

Table III. gives the actual working qualities of seven vessels, and indicates how their lengths as built compare with the calculated lengths.

* Estimated from the 400-ft. ship in relation to the deadweight.

DIE-CASTING OF ALUMINIUM-BRONZE.*

By H. RIX and H. WHITAKER, M.Sc.

DIE-CASTINGS may be defined as "finished castings, made by pouring molten metal, flowing by gravity or under other external pressure, into a metallic mould."

Advantages of Die-Casting.—Some of the advantages of die-casting are :—

1. The accuracy and uniformity of the castings. They can be made to specification 0.005 per inch, or even less for small parts.

2. Machining costs are either eliminated altogether or are greatly reduced.

3. The process is continuous, and the output is generally much greater than is the case with sand-casting.

4. Articles which it would be impossible to sand-cast may be successfully die-cast.

Although the process has been in operation for over twenty years, it is only during the last ten years that it has assumed importance as a separate industry, and this is largely due to the development of the automobile and aeroplane.

Metals Employed.—The alloys employed may be divided into five classes, according to whether the principal constituent is (1) zinc, (2) tin, (3) lead, (4) aluminium, (5) copper.

Owing to their low melting-points, alloys of the first three classes were initially employed, but the castings lacked strength and rigidity. An average zinc base alloy has a tensile strength of about 8 tons per square inch, with practically no ductility, but these alloys are very liable to corrosion and distortion.

The tin and lead-base alloys include a large number of the "Babbitt" or bearing metal type, and many bearings are now being die-cast.

The low specific gravity, cheapness and strength (when alloyed) of aluminium, have been the principal factors in its development as a die-casting metal. The chief drawbacks are :—

(1) Its high melting-point (compared with lead, tin, and zinc).

(2) Its tendency to attack iron when molten.

(3) Its high shrinkage.

(4) Its weakness at high temperatures.

On account of (2) the "plunger" type of machine has been largely superseded by one employing air-pressure, or by utilising the pressure of the riser or gate. A die using zinc-base alloys lasts almost indefinitely, but, when using aluminium alloys, cracks begin to show after 2,000 or 3,000 castings have been made. The high shrinkage of aluminium has been reduced by alloying, and need not exceed about 1.4 per cent.

The weakness of the alloys at high temperatures is responsible for the formation of cracks which develop while the metal is solidifying in the mould. Thus the strength of the copper-aluminium alloy containing, say, 12 per cent. copper drops from 8 tons to 10 tons per square inch at 0 deg. C. to 3 tons to 5 tons at 350 deg. C.

Notwithstanding these drawbacks, aluminium alloys of very variable composition are being successfully die-cast on a large scale.

Brass and Bronze Die-Casting.—The next step in the process was to surmount the difficulties connected with copper-base alloys, which have a much higher melting-point. The literature on the subject is as yet very scanty, but most of the workers in the field express the opinion that brass or bronze die-casting is almost a commercial impossibility. On reading the accounts of the work done by the Doehler Die-Casting Company,* Work,† Webber,‡ Schulz,§ Pack,‖ and Norton,¶ one arrives at the following conclusions :—

1. The chief difficulty in the process is the high temperature (900 deg. to 1,000 deg. C.) for casting "yellow metal." This has several effects. The zinc in the brass attacks the steel die, which rapidly deteriorates, so that no more than 1,000 castings can be obtained. The high shrinkage of brass sets up strains within the die which further impair its accuracy. Since the die cost (anything from 5*l.* to 200*l.*) is the prime factor in die-casting, this is a serious matter. For the same reason it is impracticable to use an iron container for the molten metal, as the alloy would rapidly become contaminated thereby; hence air pressure cannot be employed to force the metal into the die. This means pouring from the crucibles, with consequent slowing down of production, if (as is often necessary on account of expense) only one die can be used. Another consequence of the high temperature and slow pouring is the large amount of dross which is formed. Also ordinary brasses are not sufficiently strong at high temperatures to withstand the shrinkage strains which are set up.

2. It is very difficult to produce brass die-castings which are consistently free from blowholes or shrinkholes. The former are caused by air being entrapped in the mould, and they cannot be overcome by simply increasing the pressure in the mould or by carrying out the process *in vacuo*. By a careful study of the venting and gating of each part, however, this unsoundness may be practically eliminated.

3. Brass and bronze die-castings are only a commercial success if the parts cannot be completely produced by automatic machinery, or when they obviate numerous difficult machining operations, involving different settings of tools. To compete with the machined products the die-castings must be rapidly made, must be accurate to within ± 0.002 per inch, and must have a smooth polished surface. Recent developments in foundry and machine shop practice have made it possible for many parts to be now more cheaply sand-cast, and "yellow" metal die-casting is "practically restricted to pieces of fairly simple shape, weighing between ¼ oz. and 3 lb."

The experiences of the authors in this connection have been chiefly in the case of brass (60 : 40) containing about 2 per cent. aluminium; manganese brass; and "aluminium-bronze" containing iron. In the first case, the aluminium is added to give fluidity to the metal and better definition to the castings. In the second case manganese brass of usual composition is used, containing less than 1 per cent. manganese, with a little iron and aluminium. The chief objection to these metals is that the surface of the die becomes rapidly covered with a coating of zinc oxide, which must be brushed off after every cast or the definition is spoiled. Various methods have been tried to overcome this difficulty, but so far without complete success. Our best results, however, have been obtained with "aluminium-bronze" containing iron. The first alloys experimented with were of copper-aluminium containing about 10 per cent. aluminium, the balance being copper. The results were disappointing, for the metal did not lie so "kindly" to the surface of the die as it might have done, and the definition of the edges was poor. After repeated trials it was decided to add a little iron, when much better results were obtained.

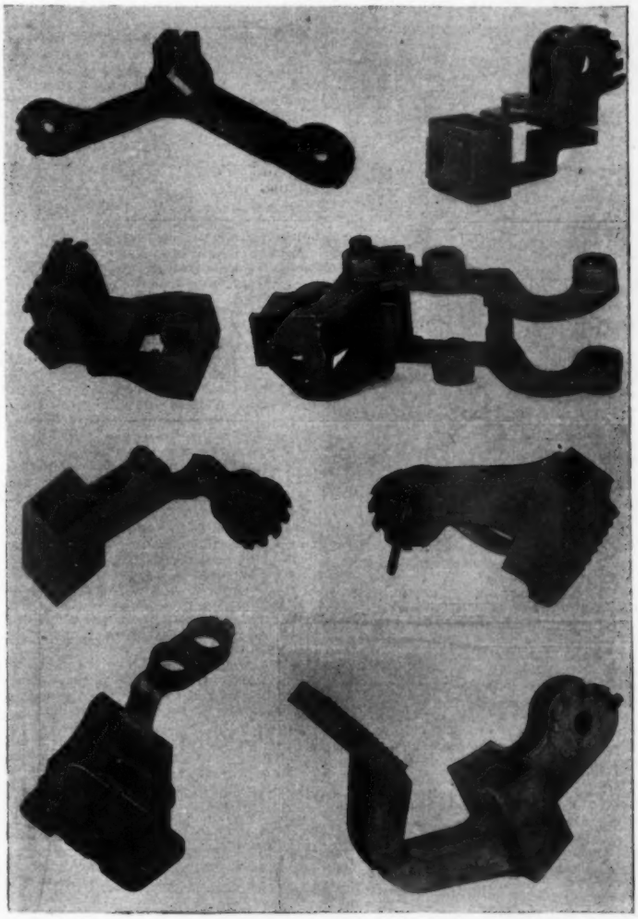
In their masterly research on the copper-aluminium

* Paper read before the Institute of Metals on Wednesday, March 13, 1918.

* Doehler Die-Casting Company, Brooklyn, N.Y.
† *Mechanical World*, October 8, 1915.
‡ *Machinery*, January, 1916.
§ *Mechanical World*, July 21, 1916.
‖ Transactions of the American Institute of Metals, 1914 and 1915.
¶ *Ibid.*, September, 1914.

alloys Carpenter and Edwards* brought the investigation to a point "where the way is clear for investigating the influence of a third metal." Rosenhain and Lantsberry,† in their introduction to the Ninth Report, discuss the reasons which led to the selection of manganese as the third metal, and it is rather singular that iron does not seem to have been considered as even a possibility. Vickers‡ alludes to the prejudice which appears to exist in the minds of most foundrymen against iron in copper alloys, probably due to its harmful effect when present in brass in any quantity. He also states that the use of iron in "aluminium-bronze" is no new thing, but has been common in Germany and the United States for some years. While claiming that it improves the metal for sand-casting, he questions its use in die-casting, for the following reasons :—

1. In sand-casting it is necessary to add iron in order to prevent the "excessive crystal growth" which is "such a drawback to the 10 per cent. aluminium-bronze."



Examples of Aluminium Bronze Die-casting Work from Iron Dies.

In die-castings this is not necessary, as the chilling effect of the die is sufficient to keep down this growth.

(That the iron has this effect was shown by Corse and Comstock.§ Combined probably with aluminium and copper the iron is the first constituent to separate out, in the form of small black crystallites, which form nuclei round which the α-solution crystallises, thus reducing the grain size.)

2. Iron accentuates the shrinkage of the bronze, consequently increasing the tendency to form the pear-shaped cavities commonly found in aluminium-bronze die-castings.

The authors do not agree with the above conclusion limiting the usefulness of copper-aluminium-iron alloys to sand-castings, having produced many thousand die-castings in these alloys. The cavities referred to are certainly a difficulty to be overcome. They are either shrink-holes, caused by the large contraction of the metal, or blowholes caused by air being entrapped in the die by the molten metal, and they may be detected in a casting by finding its specific gravity. Their direction is often radial, and they may be coloured black inside. In either case, they may be practically eliminated by a careful study of gating, venting, &c.

Tetmajer* has worked with "aluminium-bronze" containing iron and silicon, but what appears to be the most complete account of the copper-aluminium-iron alloys is by Corse and Comstock.†

They have studied the properties of the possible combinations containing 1 per cent. to 4 per cent. iron and 7 per cent. to 10 per cent. aluminium inclusive. Their conclusions are that "for the same aluminium content there is always an increase of proportional limit, yield point, and ultimate tensile strength with increasing iron content, and in general a rather less substantial decrease in elongation and reduction of area. In the same way, with constant iron content, the proportional limit, yield-point, and ultimate tensile strength increase with increasing aluminium, while the elongation and reduction of area decrease. Also, that for a given strength, better ductility can be obtained with a lower aluminium and high iron alloy, than with higher aluminium and low iron."

It is, of course, difficult to compare the results of different workers on similar alloys, owing to lack of uniformity in methods of preparation and testing, but a comparison of the results contained in the Eighth and Ninth Reports to the Alloys Research Committee, and those obtained by Corse and Comstock, leads to the following conclusions :—

1. Iron and manganese, when added respectively to copper-aluminium alloys (containing 7 per cent. to 10 per cent. aluminium), have a similar effect, i.e., the yield-point and ultimate tensile strength are raised at the expense of the ductility.

2. In the case of sand-cast bars, the addition of iron appears to give better all-round mechanical properties than the addition of an equal amount of manganese. The data are not available for a complete comparison of the chill cast bars, but some promising results have been obtained by the authors with alloys containing 7 per cent. to 10 per cent. aluminium and 1 per cent. to 4 per cent. iron. The authors are producing die-castings commercially in one of these alloys, and the following are the average results recently obtained from 24 test bars, cast in 1-in. chill and cooled in air.

It should be pointed out that each bar represents a batch of castings, produced consecutively during a period of several months, under ordinary foundry conditions.

Diameter of Test-section.	Yield-Point.	Ultimate Tensile Strength.	Elongation on 2 In. per Cent.	Reduction of Area per Cent.
in.	tons per sq. in.	tons per sq. in.		
= 0.564	14.7	35.5	24	21.8

These results compare favourably with those for the chill cast bars containing 7 per cent. to 10 per cent. aluminium given in the Eighth Report, and for those containing 8 per cent. to 10 per cent. aluminium and 1 per cent. to 5 per cent. manganese given in the Ninth Report. In several cases the latter alloys give better results, but whether they may be die-cast or not is open to question.

Heat Treatment.—The mechanical properties of the copper-aluminium-iron alloys may be profoundly modified by heat treatment, and this probably accounts for the variable results obtained with the same metal under ordinary casting conditions. Consequently, accurate pyrometric control of the die-casting process is advisable, if consistent results are required. The temperature of the molten metal should be known, and that of the die itself, also the rate of cooling of the hot casting should be standardised. Much different mechanical properties would result if instead of quenching the casting red hot from the chill, in cold water, it were allowed to cool slowly in air.

An advantage of the alloy used by the authors is that it is sufficiently fluid to fill the die and give satisfactory castings through a wide range of temperature.

Material for Dies.—The authors have experimented with several materials, ferrous and non-ferrous, for die-making, but have had the best results with a close-grained cast-iron, as hard as is consistent with good machining properties. The block of iron from which the die is made is itself chill cast, to give these qualities. Sometimes the dies have been cast almost to shape before machining, but the results have not been very satisfactory.

It need not be pointed out that a die when once made is only suitable for one particular alloy. Each alloy has its own requirements regarding gating, venting, and shrinkage, and the particular problems of each new part render it very difficult to make a correctly designed die at the first attempt. In an iron die as described above, there can be made from 5,000 to 7,000 castings similar to the "Butterfly" type of carbon brush-holder (marked No. 1) that is shown, along with other examples of die-casting, on this page, before it shows signs of deterioration. No facing or special treatment of the die surface is necessary, nor is the die cooled down every few minutes; but the plugs, which are of steel, are dipped in a graphite wash between each cast to preserve their shape; even then they do not last so long as the die. The other illustrations represent chiefly different types of carbon brush-holder, all of which are being die-cast on a commercial scale. The design of the die is a most important factor, and here it is where experience is the best guide. The design of the part itself should conform to the special requirements of die-casting, and there is need for the closest co-operation between the engineer, metallurgist and foundry foreman. The number and shape of the part of the die, method, and order of withdrawing the cores, venting, situation, shape and size of the gate, all must be carefully considered in designing a new die.

Cost of Process.—No general rule can be laid down with regard to costs. In some cases die-casting is cheaper, in other cases dearer than sand-casting. The cost of dies, material, labour and machining must be gone into before a decision can be come to as to which is the more economical process. The cost of machining and assembling of the "Butterfly" type brush-holder above referred to is eight times as great when sand-cast as it is when die-cast, and the other parts shown are also cheaper die-cast. The castings are not sold by weight, as the cost of labour varies both in making the dies and castings. The die cost is treated as a separate item from that of the castings, and is generally borne directly by the customers.

Die-Casting on a Scientific Basis.—For a scientific investigation into die-casting, the following might be carefully studied :—

The alloy :
(1) Coefficient of expansion at different temperatures.
(2) Specific heat.
(3) Thermal conductivity.
(4) Mechanical properties at high temperatures.
(5) Mass, volume and surface area of casting.
(6) Latent heat of fusion.
(7) Metallography.
(8) Pressure on metal in die.

The die-material :
(1) to (5) As above.
(6) Possible attack by molten alloy.

Casting conditions :
(1) Temperature of molten metal.
(2) Temperature of die.
(3) Length of time in die.
(4) Rate and method of cooling of casting.

Even with all the above information, however, it would still be necessary, in the case of a new part, to go on more or less empiric lines before a satisfactory casting could be produced.

It might be feasible to design a standard die which

* Carpenter and Edwards, "Eighth Report to the Alloys Research Committee," 1907.
† Rosenhain and Lantsberry, "Ninth Report to the Alloys Research Committee," 1910.
‡ *Mechanical World*, August 17, 1917.
§ Transactions of the American Institute of Metals, September, 1916.

* *Mitteilungen der Material-prüfungsanstalt*, IX Heft.
† Transactions of the American Institute of Metals, September, 1916.

would serve as a basis for comparison of results obtained by different observers.

Conclusion.—One of the authors previously quoted summarises the position by saying that "the principal secret of die-casting is experience, which is the result of tireless effort, skill, patience and—capital."

The thanks of the authors are due to the British Westinghouse Electric and Manufacturing Company, Limited, for permission to publish the above paper and the accompanying photographs.

THE EMPLOYMENT OF WOMEN IN MUNITION FACTORIES.*

By Miss O. E. MONKHOUSE, M.B.E., B.A.(Lond.).

Introduction.—At the outset the author wishes to acknowledge the compliment accorded to her by this Institution of being asked to give her views on the employment of women in engineering works. Her appreciation is increased in so far as the request preceded the passage through Parliament of the measure giving the franchise to women.

At the beginning of the war it was an exceptional thing for women to be employed as general machinists and fitters in engineering shops, but the demand for a greatly increased supply of labour of all kinds for munitions production, and at the same time the necessity for conserving the man-power of the country to the fullest extent, made it necessary for the Government to turn to the largest source of supply of unskilled labour, namely, women. The successful employment of women in engineering works depends not only on the unskilled woman, but in an almost equal degree on the skilled man, and the employer.

The Employer.—The successful employer of women labour faces the question of dilution squarely, and recognises at the outset that the psychology of the woman worker is different from that of the man. Next he fixes on work suitable for his new type of employee, and then determines the quickest and easiest way to train her in the work. He assures himself of the extent to which the men will co-operate, and is always careful to provide suitable shop conditions and plant, &c. Having made these preliminary arrangements, he realised the necessity for carefully choosing the right class of labour, and his next step is to appoint a woman of experience to engage and look after the women, and to select as their technical overseer a foreman who he knows is sympathetic with his new venture.

The Skilled Man.—The skilled men have to do the technical training, and have to use all their brains and skill in order to train inexperienced women. They have to sectionalise work, adapt machinery, and simplify operations so as to make it possible to employ women. In their hands is largely the power to oppose and retard all progress by women on skilled work, because at the outset hardly a single woman is in a position to know when obstacles are being placed in her way. She perforce has to rely entirely on their generosity, and her position in engineering shops to-day shows that she has not relied in vain.

On the other hand, it must be remembered that every man does not make a teacher, and that every teacher of men is not necessarily a suitable teacher of women. Thus the unequal success of women in different shops is due in a measure to this cause as well as to antagonism on the part of the men.

The Unskilled Woman.—The successful woman worker in an engineering works has a great deal to learn, because in addition to learning her work she has to acquire correct work habits, and face obstacles both necessary and unnecessary which are constantly put in the way of her becoming efficient.

There are, however, three grades of unskilled women who must be taken into account :—

1. The educated type.
2. The domestic type.
3. The ordinary factory type.

The educated type came with trained brains ; they know how to learn and how to apply their knowledge. They probably have mathematical training and can be taught in a very short time how to use a slide rule, a micrometer, and other gauges. Fine limits present no difficulty to them, and in a sense they may be regarded as already half educated for the better class of engineering work.

The second type, namely, the domestic type, drawn mostly from the daughters of small tradesmen, generally have a good deal of sound commonsense, are reliable, and enjoy, and so aim at securing, some position of authority. Such people train quite readily into good charge hands and forewomen.

The factory type are different from either of the other two—they are mainly concerned with making as much money as they can, and preferably on piece-work. For the most part they resent being put on to a new operation because, every time they learn anything fresh, it means a temporary set-back in wages. It has therefore been found best to employ such workers on purely unskilled work of a repetition nature.

But no matter what the type of unskilled women, it must always be borne in mind that their success depends largely on the judgment of the management in selecting a good class of women labour. At the present moment there are, roughly speaking, close on 1,000,000 women employed on the production of munitions of war.

The introduction of all these women into engineering shops meant that a great many difficulties had to be overcome. These may be briefly summarised as follows :—

1. A very large proportion of the women employed not being accustomed to factory life and discipline.
2. The majority of works managers and foremen not being accustomed to managing women workers.
3. The shop conditions for the most part planned with a view to the employment of men.
4. The use of the machinery to which women have hitherto been unaccustomed.
5. The difficulties of maintaining discipline in a mixed shop and in entirely female shops staffed by women of no previous factory experience.
6. The long hours.
7. The question of physical strength.

Many of these difficulties have been overcome by careful selection of suitable work, a careful choice of labour, proper shop organisation, conforming to definite welfare standards, installing or adapting plant suitable to women's use, supplying proper training facilities, sub-dividing skilled work and adapting the hours of employment in accordance with the class of work done.

How Women Have Reached their Present Skill.—At the stage which women have reached at the present moment in engineering, nothing but harm can be done by praising their powers too highly, but there are many individual cases where women have shown very great ability, and have acquired a knowledge of a certain branch of engineering work in excess of what would have been learnt by an apprentice in the same period under pre-war conditions. This state of affairs may be attributed very largely to three causes :—(1) Women have been definitely taught, whereas the apprentices had to pick up their trade. (2) Women have, for the most part, been intensively taught everything in the shop itself under production conditions rather than in the school. (3) The conditions of the time have actuated and spurred on everybody to greater effort, from patriotic motives.

Training of Women Workers.—There is little doubt that the advantage of getting their training under production conditions has been very largely instrumental in considerably speeding-up women's training, and the author would like now to consider some of the methods in use for training women workers.

Women Trained in Works in a Separate Shop.—It is extremely difficult to start women in the same shop with men, unless the latter are in sympathy with the movement, and experience has proved that the only satisfactory way is to start women in a shop by themselves under a sympathetic foreman until they have proved themselves. In illustration of this the author can quote a firm who, up to last April, had no women bench fitters on aircraft work. They have adopted the above plan, and there are now 200 women fitters in the shop controlled by women charge hands, all doing exceedingly well.

Overcoming of Incredulity on Part of Management.—Another type of case which should be mentioned is that of firms who cannot believe that women can do anything but purely repetition work, and regard a woman fitter, tool-turner, or tool-setter as an impossibility. It therefore is no use telling them that they must up-grade their women on to better work ; they have to be shown that women are available in numbers who can do such work. In such case the Ministry often sends to the firm an expert woman demonstrator. She will first of all do the job herself in the shop to prove its practicability, and she will then continue to assist the firm by training some of their best operators or helping them to select others who are suitable. There are many firms which, having been assisted in this way, have become some of the most successfully worked shops in the country, not only from the point of view of percentage of women labour but of record output as well.

Other Successful Methods of Training Women Workers.—It would take up too much time to go through at length all the various methods which have had to be adopted in order to make women efficient in the shortest possible time. Government training schools have done much by supplying a nucleus of semi-trained labour to shops desiring either to make a start with women labour or to introduce women on to some new class of work. Just a few large firms have done the ideal thing and set up their own training schools, from which they have a continual flow of semi-trained labour always ready to draw upon.

Characteristics of Women.—All consideration of women's work must be accompanied by a careful appreciation of the mental and physical characteristics of women. They have shown great adaptability and natural skill in successfully undertaking work of an entirely new character, but the varying degrees of success points to the necessity for thoroughly understanding their peculiar temperament if the best results are to be obtained.

Shop Organisation.—Firms, who with male labour have been thoroughly successful, have failed when forced to employ women labour, thus proving that they did not understand their new employees. Other managers have not recognised their own failings clearly, and numerous cases can be quoted where the want of success of women labour has been traced to defective shop organisation. By this term is meant the question of supervision and direction of the work in the factory—work usually performed by foremen and male charge hands. A foreman may be an admirable foreman of men, and at the same time an unsuitable foreman for women, apart from the question of his technical ability. There is no doubt that women do need special management, and it is folly to disregard the human element, as some do, by asserting that if women are to be employed on men's work, they must be treated the same as men. In one sense this is true. Discipline and strict adherence to work should be expected from women just as much as from men. As a rule men are either too lenient or too stern in their treatment of women, or too busy to study their peculiarities, and experience has shown that women should be controlled and organised by their own sex if the best results are to be obtained.

Shop organisation, however, even when performed by women, may be quite unsuccessful if proper judgment is not used when selecting people for this work, and this brings up the general question of the choice of woman labour.

Choice of Labour.—There is no doubt that generally speaking a woman is a better judge of a woman than a man, and successful firms have realised this and have appointed an experienced woman supervisor, to be responsible for engaging all their women labour. Very recently a case came to the author's notice of a factory where one side of the labour was chosen by a woman and the rest by a man. There was great complaint of the efficiency of the latter, but none of the former. Investigation showed the cause that those women who were "turned down" by the woman supervisor were generally engaged by the man.

Ordinary Labour.—In the choice of ordinary operatives, stability of character and suitable physique must be the main considerations, but different characteristics must be taken into account when choosing forewomen and charge hands. It is most essential that such people should have shop experience coupled with a certain amount of technical knowledge, and a thorough knowledge of how to manage women, and ability to hold their own in the shop. Women taking up this work must have tact and discretion, and the necessary power to enable them to work in harmony with the shop manager, whose authority should not be interfered with. Generally speaking, the most successful forewoman and charge hands have been drawn from the more educated classes. For it must be remembered that women as a whole have been introduced very quickly, in very large numbers, without proper training or proper discipline, and it needs someone with powers of leadership and organisation to get the women labour going on a proper footing.

Welfare.—Placing in factories in such large numbers women, many of whom have never been accustomed to factory life or conditions, has also called for special considerations of welfare conditions on the part of the employers. In considering this question two points of view must be taken into account : (1) Effect of Welfare on Production ; and (2) Effect of Welfare on the Race.

Effect of Welfare on Production.—Employers have now for the most part fully realised that to give their women good welfare conditions is a sound business proposition. Without such provision they cannot get a good class of labour. The unwonted heavy muscular effort and constant strain through which they are working makes it essential that their off times should be restful, if good work is to be done after the break. Good canteen accommodation also is most important, and there have been cases where managers have found that to provide one good meal a day free of cost has been more than repaid to them in output.

Welfare on the Race.—But quite apart from the effect of welfare on production is the effect of welfare on the race. From the national point of view this is the most important aspect to consider. For this reason the Health of Munition Workers' Committee was formed, whose special care was to safeguard any deterioration of the race which might perhaps accrue from women being compelled to work in all great industries. They have considered carefully (1) the hours of work ; (2) rest periods and provision for meals ; (3) sanitary conditions of the factory ; (4) physical condition of women workers ; (5) questions of management and supervision.

Hours of Work.—With regard to hours of work, experience has shown that a reasonably short shift is the most successful, producing less industrial fatigue as shown by few accidents, better timekeeping, and undiminished capacity of the worker towards the end of the shift so that a better average output is maintained. Another point in favour of shorter hours is the fact that a better class of labour is tempted to join the ranks of munition workers.

The other problems the committee have considered in full detail, and the result of their investigation has shown that the nation is under a definite obligation to consider women's health and comfort in the factories if they are to protect and safeguard their position as the mothers of the race. Experience has shown that wherever there has been proper consideration for women's welfare in factories that there has been not only no decrease in healthy physical development, but a decided increase in mental capacity. It has been an enormous advantage for women to have had this opening into a wider field of skilled and semi-skilled work, and the country has benefited by a tremendous increase of industrial efficiency.

It must be remembered that a woman's work is not ended when she leaves the factory. On her largely depends the life and happiness of the nation in creating and developing a happy, healthy family life, and it is her privilege to care for the physical and spiritual welfare of the race. Added industrial efficiency therefore at the expense of women fulfilling their primary duties in their homes and to their children cannot result in anything but national disaster, and it is a sacred duty of the State to ensure that women are only used as wealth producers in so far as it does not affect the healthy development of the race.

* Paper read before the Institution of Mechanical Engineers, Friday, March 15, 1918.

ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN.—The Newcastle and District Branch of this Association have issued a portion of their report for the winter session 1917–18, page 181 to 216, which deal with the determination of Ships' Proportions and Machinery Dimensions, and with the Design of Screw Propellers.